THE UNITED STATES DISTRICT COURT FOR
SOUTHERN DISTRICT OF NEW YORK

GENOA COLOR TECHNOLOGIES, LTD., Plaintiff, v. MITSUBISHI ELECTRIC CORP.; MITSUBISHI ELECTRIC US HOLDINGS, INC.; MITSUBISHI ELECTRIC AND ELECTRONICS USA, INC.; MITSUBISHI DIGITAL ELECTRONICS AMERICA, INC.; SAMSUNG ELECTRONICS CO., LTD.; SAMSUNG ELECTRONICS AMERICA, INC. Defendants.	No. 07-CV-6233 (PKC) (JURY TRIAL DEMANDED)

Declaration of Louis D. Silverstein, Ph.D. in Support of the Plaintiff's Proposed Claim Construction for U.S. Patent No. 7,113,152

I, Louis D. Silverstein, hereby declare as follows:

I. INTRODUCTION

In the case of Genoa Color Technologies, LTD (Plaintiff) versus Mitsubishi Companies and Samsung Companies (Defendants), I have been retained as an expert witness by the Plaintiff, as represented by the firm of Lahive & Cockfield LLP. I have been selected as an expert witness for this case because my education and experience well qualifies me as one of ordinary skill in the arts of display technology and color science. In my role as an expert witness for the Plaintiff, I have been requested perform the following activities: 1) to investigate and render expert

opinions on the scope and validity of the intellectual property of the Plaintiff as described in issued U.S. Patent No. 7,113,152 (the "'152 patent") entitled "Device, System and Method for Electronic True Color Display;" 2) to offer interpretation and support meaningful and correct claim construction for the '152 patent; 3) to evaluate the veracity of invalidity assertions of the defendants against the claims of the '152 patent; and 4) to assist in the determination of whether the activities and products of the defendants infringe on the intellectual property of the Plaintiff as manifested in the claims of the '152 patent.

The core technical issues in this case involve the development, performance optimization and systems integration of electronic color displays for television and information display applications, with particular emphasis on the use of more than the typical three color primaries (RGB) which are the minimum required to synthesize full-color images. Utilization of greater than three primary colors for electronic display image generation can yield substantial gains in the color gamut of images which can be displayed as well as potential improvements in other aspects of display image quality and light throughput efficiency. However, the successful development and deployment of multi-primary (> 3 primary colors) display systems requires unique solutions for both display system hardware components and algorithms for effective color and image management. Moreover, a careful co-optimization of multi-primary display system hardware and processing algorithms are required to fully realize the color imaging potential of using in excess of three primary colors for electronic displays. It is evident that the Plaintiff, Genoa Color Technologies, LTD (hereafter referred to as "Genoa"), recognized these essential aspects of multi-primary display systems in their teachings, initial invention descriptions, formal as well as provisional U.S. and foreign patent applications, and the issued '152 patent.

It is my understanding that a patent infringement analysis involves two steps: (1) construction of the patent claim at issue, followed by (2) a comparison of the claim thus construed to the accused device. I further understand that the words of the claims are generally given their ordinary and customary meaning, which is the meaning that the claim term would have to a person of ordinary skill in the art at the time of the effective filing date of the patented invention. As such, I have been requested by the Plaintiff to support the meaningful and correct claim construction for the '152 patent and to submit this declaration both as documentation of my opinions and in anticipation of my testimony before the court.

II. EXPERT WITNESS CREDENTIALS

For approximately the past 28 years I have been actively engaged in research, development and technical consulting focused on the synergistic interface between the human visual system (HVS), including its capabilities and limitations, and electronic display systems. The broad objective of my work has been to improve visual display technology through the optimal matching of HVS characteristics and the performance parameters of visual displays. The application of principles of vision science and color science to electronic imaging systems in general, and electronic displays in particular, encompass my principal areas of specialization.

Currently, I am the President and Chief Scientist of VCD Sciences, Inc. located in Scottsdale, Arizona. I founded the company in July of 1990 to provide a repository of technical consulting expertise in the areas of applied vision, color science and display technology. VCD Sciences, Inc. has been successfully engaged in such consulting activities over the past 18 years with over 25 clients from both industry and government research laboratories. Prior to founding VCD Sciences, Inc., I held a number of research and development positions in various

corporations including Honeywell, Inc., Sperry Corporation, the Boeing Company, General Physics Corporation and Rockwell International. All of these positions involved a major project focus on various topics in applied vision, color science and display technology. In my last position prior to leaving industry, I directed a corporate display research group at Honeywell, Inc. and achieved the title of Senior Corporate Research Fellow.

Preparation for my scientific career has come from both my formal education and broad range of academic and professional activities. I received my B.S. degree in Experimental Psychology in 1972 and my M.S. and Ph.D. degrees in 1974 and 1977, respectively with a major emphasis in Psychophysics and Vision Science. All of my degrees were received from the University of Florida in Gainesville, FL. After completion of my Ph.D., I was awarded a two-year postdoctoral fellowship from the National Institutes of Health to pursue advanced training in sensory neuroscience at the University of Wisconsin in Madison, WI. Over the course of my career I have published more than 120 journal articles, book chapters, conference papers and technical reports. I am a member of numerous technical societies, have been elected as a Fellow of the Society for Information Display (SID) and serve as a U.S. delegate to the Commission Internationale L'Eclairage (CIE). I have also served a four-year appointment to the National Academy of Sciences/National Research Council Committee on Vision. I have served and continue to serve in various editorial positions for a number of scientific journals and remain on the editorial board of the journal *Color Research and Application*. I have served as the technical and general chair of conferences devoted to display technology and color science and routinely teach seminars and courses on these topics, including the longest running seminar in SID history on "Color in Electronic Displays" and a SID short course on "Fundamentals of Vision and Color Science for Display Technologists." I have been the recipient of numerous awards for my work

on color display technology from the SID, the Inter-Society Color Counsel, the Human Factors Society, and corporate employers. I have been issued 28 U.S. patents on display technology as either inventor or co-inventor and currently have an additional 7 patents pending. A true and correct copy of my Curriculum Vitae is provided as Exhibit A of this report.

My participation as an expert witness in this case is supported by compensation from the Plaintiff at a rate of $450 per hour for my services plus expenses. However, the opinions expressed in this report are my own, and my compensation in this case is independent of those opinions or the outcome of the case. Prior to my participation in this case, I have testified as an expert witness in only a single case involving an intellectual property dispute. That case was settled prior to scheduled binding arbitration hearings, and my testimony was limited to a pre-hearing deposition. In addition, I have provided expert analytical support to several other patent litigation cases involving display technology.

III. SCOPE OF THE DECLARATION

In this declaration I provide an overview of the current technology and issues relevant to the ‘152 patent and offer interpretation of the claims from the perspective of one of ordinary skill in the arts of display technology and color science. The objective is to support meaningful and correct claim construction for the ‘152 patent. The remainder of this declaration is organized into five additional sections. Section IV provides a listing of the principal case documents which were considered in support of claim construction for the ‘152 patent. Section V provides basic background material to facilitate an understanding of the principal technical issues in this case. This section contains a brief overview of color vision, color science and their application in color display technology. In addition, Section V provides a basic description of color image formation and color management issues as they relate to the multi-primary display technology at issue in

the ‘152 patent. Section VI discusses the implications of the previous sections for claim construction and introduces the Plaintiff’s proposed claim construction. Section VII contains a certification that this declaration reflects my own opinions as an expert witness in the case. Finally, Section VIII provides a list of reference materials used in development of the background section.

IV. PRINCIPAL CASE DOCUMENTS CONSIDERED REGARDING CLAIM CONSTRUCTION

The principal case documents I have reviewed for this declaration supporting claim construction for the ‘152 patent include the following:

- U.S. Patent No. 7,113,152 issued on Sept. 26, 2006 and filed on June 7, 2001 as a continuation of Application No. 09/710,895 filed on Nov. 14, 2000 (herein referred to as Genoa’s ‘152 Patent).
- U.S. Provisional Patent Application No. 60/209,771, filed on June 7, 2000 by Genoa as the first application describing the invention contained in the ‘152 Patent.
- Complaint filed on July 5, 2007 in the U.S. District Court, Southern District of New York, on behalf of Genoa Color Technologies v. Mitsubishi Companies and Samsung Companies, Civil Action No. 07-6233
- Mitsubishi Companies List of Claim Terms and Proposed Constructions pursuant to Section 5.1 of the Court’s October 12, 2007 Amended Civil Case Management Plan and Scheduling Order for Civil Action No. 07-CIV-6233, dated March 3, 2008.
- Samsung Companies Identification of Terms for Construction pursuant to Section 5.1 of the Court’s October 12, 2007 Amended Civil Case Management Plan and Scheduling Order for Civil Action No. 07-CIV-6233, dated March 3, 2008.

- Joint Disputed Claims Terms Chart pursuant to Paragraph 5.2 of the Court's October 12, 2007 Amended Civil Case Management Plan and Scheduling Order for Civil Action No. 07-CIV-6233, dated March 20, 2008.

V. BACKGROUND

A. Color Vision, Color Science and Their Application to Color Display Technology

1. *Some Basics of Color Vision*

The human visual system (HVS) is sensitive to wavelengths of light within the region from 380 nm to 780 nm, known as the visible spectrum.[1] This spectrum corresponds to the colors seen in a rainbow or through a prism, with blue light corresponding to the short wavelength end of the spectrum and red light corresponding to the long wavelength end of the spectrum. In other words, the wavelengths or spectral composition of the light determines the color that the HVS will perceive. Figure 1 illustrates the emitted light spectra of several sources of light, including a standard illuminant of 6500ºK color temperature, a tungsten lamp, a green LED, and the P22 red phosphor emission from a color cathode-ray tube (CRT) display.[2] The HVS responds in an equivalent manner to color stimuli, regardless of whether the color originates as light reflected from a natural object or is emitted from an artificial light source or electronic display. How the HVS responds depends on the spectral composition of light being detected, as discussed below.

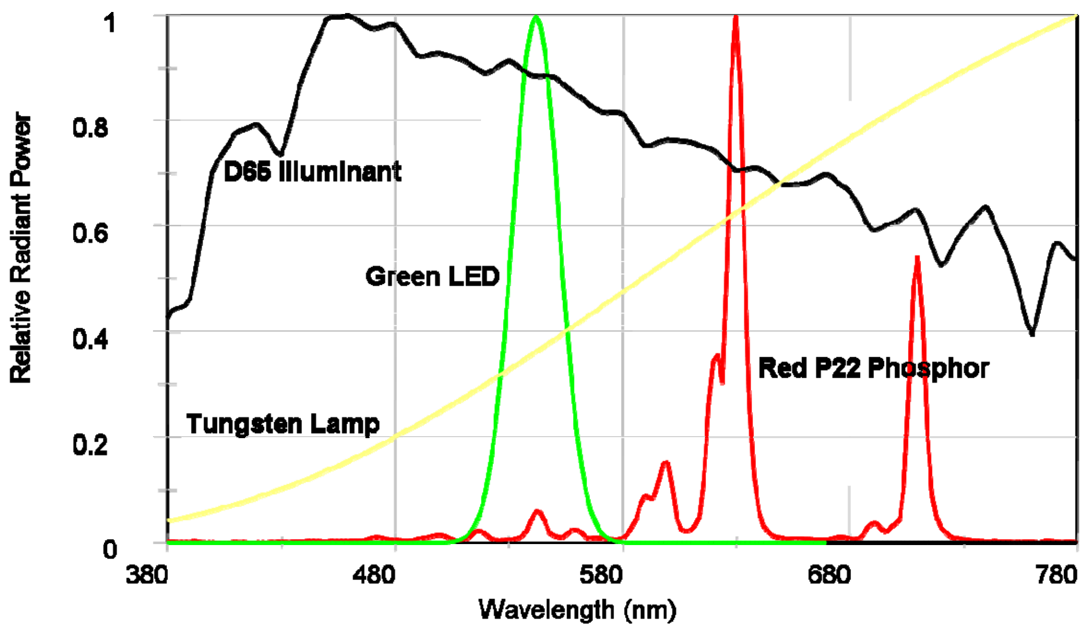

Figure 1. Spectral power distributions in the visible range for several types of light sources.

The sensitivity of the HVS varies across the visible spectrum, as described by the trichromatic theory of color vision. This fundamental theory of color science postulates that all colors are analyzed by the human visual system through three different types of response.[1,2,3,4] Each response corresponds to the spectral sensitivity of a population of photosensitive receptors in the human retina to the incoming light. Each receptor population is selectively sensitive to a finite spectral bandwidth that approximates separate long (red), middle (green) and short (blue) wavelength response functions. The resulting three responses are processed by neural circuitry in the retina and higher levels of the HVS and combined in a complex manner to produce what we ultimately experience as "color." Figure 2 provides a simplified schematic representation of the structure and functional organization of human color vision from photoreceptors through neural processing.[2]

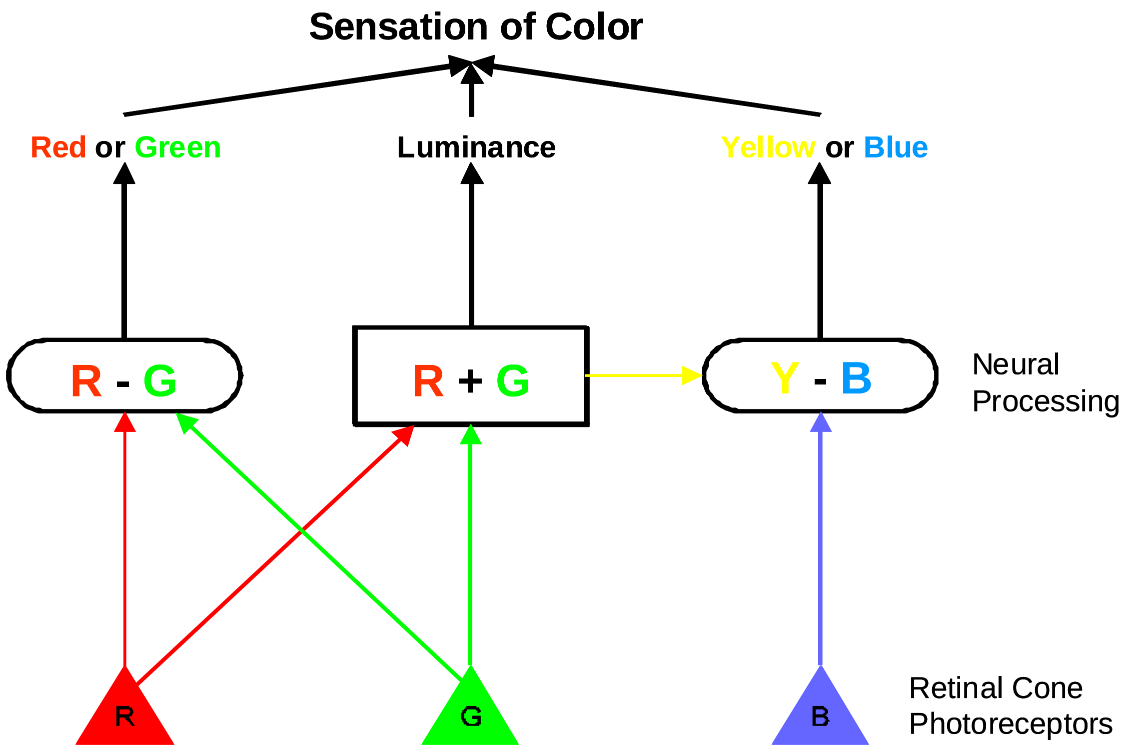

Figure 2. Simplified schematic representation of the structure and functional organization of color vision.

The variation in visual sensitivity depending on wavelength is known as the photopic luminous efficiency function. This function was standardized by the Commission Internationale L'Eclairage (CIE) in 1924 and is illustrated in Figure 3.[1] The photopic luminous efficiency function is important for color specification in that it enables quantitative estimates of the visual efficiency of light sources (or displays) according to their spectral content. In other words, some wavelengths of light are more "efficient" than others, because the human eye is more sensitive to light of those wavelengths. Human visual sensitivity is skewed towards colors in the middle range of the visual spectrum, as Figure 3 illustrates.

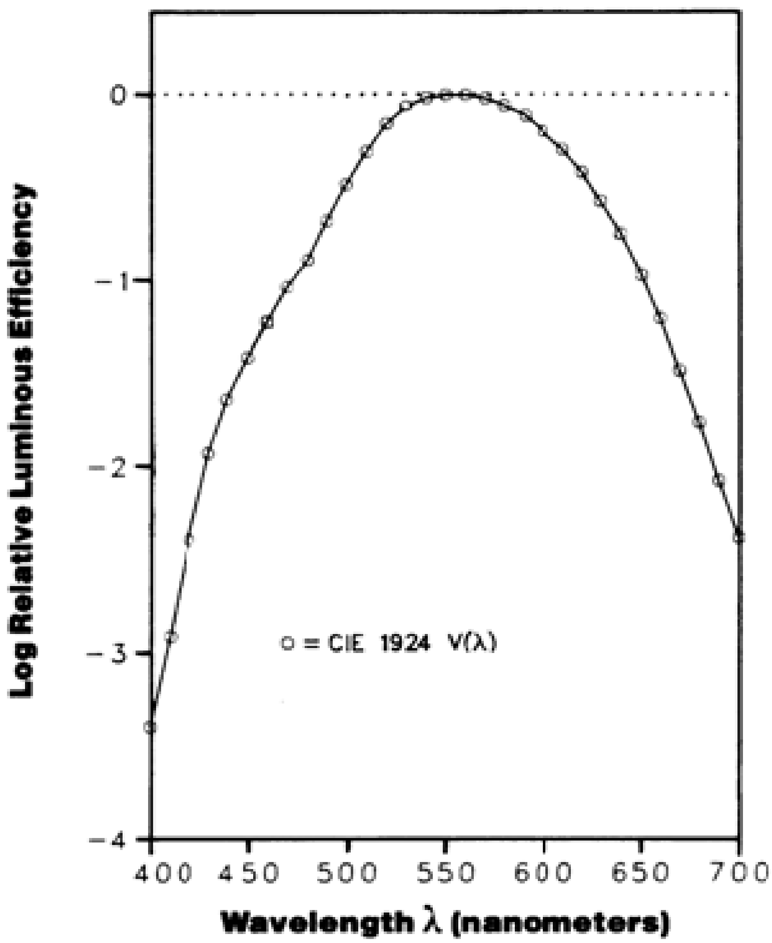

Figure 3. The photopic luminous efficiency function of the HVS.

The trichromatic theory of color vision has important implications for color display systems. A common problem for all color displays, regardless of whether they are of the self-luminous (e.g., CRTs or LEDs) or non-self-luminous type (e.g., LCDs), is the synthesis of a full-color image from a limited set of primary colors. However, because the outputs of only three distinct populations of wavelength-sensitive receptors are combined to produce our sensation of the entire spectrum of colors, the appearance of any visible color can be matched by the mixture of three appropriately selected primary color stimuli.[1,2,3]

At this point it should be noted that the spectral absorption functions of the visual cone photoreceptors possess broad regions of spectral overlap as illustrated in Figure 4.[1,2,3,4] The

implications of this spectral overlap are that trichromatic theory and practical, real-world color synthesis depart on the full scope of visible colors which can be matched by a limited set of primary colors. Trichromatic theory and the associated laws of color matching allow for the existence of negative values for primary color components and, under these assumptions, spectral overlap in the photoreceptor response functions may be negated and all visible colors may be successfully matched by only three appropriately selected primary colors. However, the real world is not so accommodating. Negative light and therefore negative values for primary colors are not physically realizable. Although such departures between the practical applications of color theory and color theory itself are perhaps best left to the color scientist, the practically reality we are left with is that a color display (such as a TV) can synthesize a substantial portion of the colors we can see but cannot generate the complete set of colors visible to the HVS by combining only a limited set (e.g. three) of different "primary" colors of light. This issue is of great importance to the topic of multi-primary color displays and the focus of the '152 patent and we will return to it in later sections.

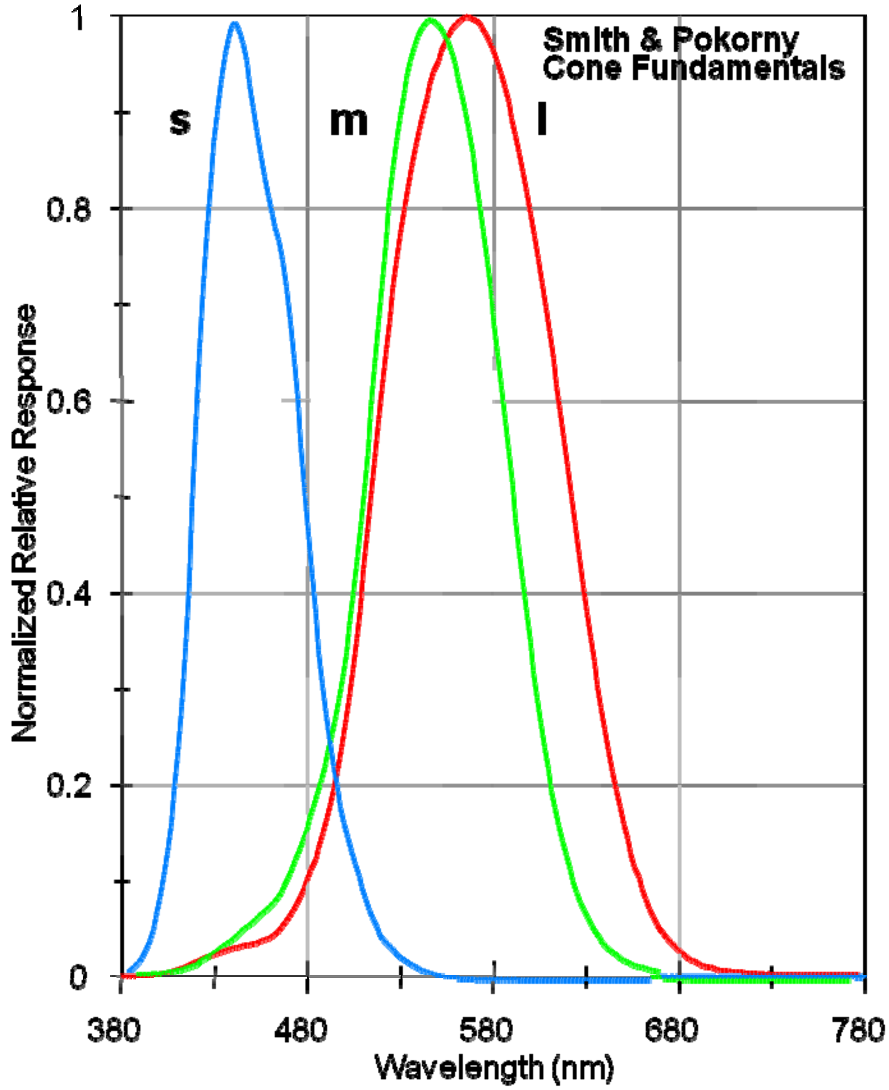

Figure 4. The normalized long (l), medium (m) and short (s) wavelength spectral response functions of the HVS.

2. *Some Basics of Color Science*

Primary colors are the set of elemental colors which can be generated and combined in various proportions to visually synthesize a range of mixture or "secondary" colors. This concept was the basis of the experiments performed by the CIE in the 1920s.[1,2,3,4] At that time, a man named W. David Wright and his colleagues established standardized methods for the color matching experiment and measured the color-matching functions for a number of observers.

This work eventually resulted in the development of the CIE color standard, and much of our understanding of how the HVS perceives and matches colors.

Participants in the experiments were asked to look at a screen in a carefully controlled optical environment. A disk of color was displayed on that screen. Half of the disk was a "test" color of a single wavelength projected onto the screen. The other half of the disk was a superposition of three different light sources: one red, one green, and one blue. The participant was asked to adjust the relative intensities of each of these RGB primaries until that half of the disk exactly matched the test color on the other half of the disk. Figure 5 illustrates the principles of the color-matching experiment.

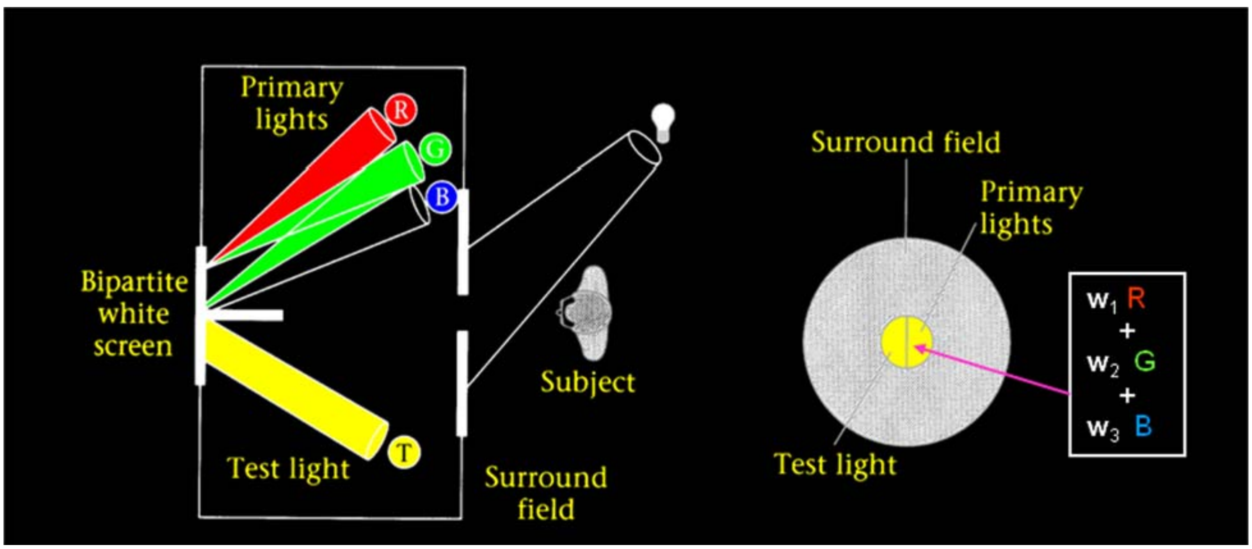

Figure 5. Illustration of the concept of the color-matching experiment.

Participants were able to perform this task because human photoreceptors are essentially photon counters. Recall that there are only three types of photoreceptors, which correspond to long (red), medium (green), and short (blue) wavelengths of light. If the photons captured by each of these photoreceptors are equal, the actual spectral compositions of the light sources are

irrelevant. In other words, the HVS cannot tell the difference between light spectra that have different wavelength distributions but the same number of photons falling into the three spectral "bins" captured by the three types of photoreceptors. This principle is known as "metamerism," and is the key to full-color displays, as discussed further below.

Dr. Wright and his colleagues recorded the precise mixture of the RGB primaries that was required to match the test colors for each participant. Wavelength by wavelength, they displayed test lights of different colors and asked participants to adjust the RGB primaries to match the test colors. By averaging the results from a number of observers, they then determined the visual response of the "average observer." Based on this data, the CIE developed what have come to be known as "color matching functions." In other words, the CIE developed mathematical functions and a system of specification to predict what RGB color mixtures would be required to duplicate any given test color. (The transformations from experimental data to standardized mathematical functions involved some theoretical assumptions and mathematics that are irrelevant for the purposes of this report.) These color-matching functions gave rise to what is known as the CIE standard colorimetric observer or color standard. The CIE color standard is commonly depicted as a plot of tristimulus values which describe the color matching functions, as shown in Figure 6.

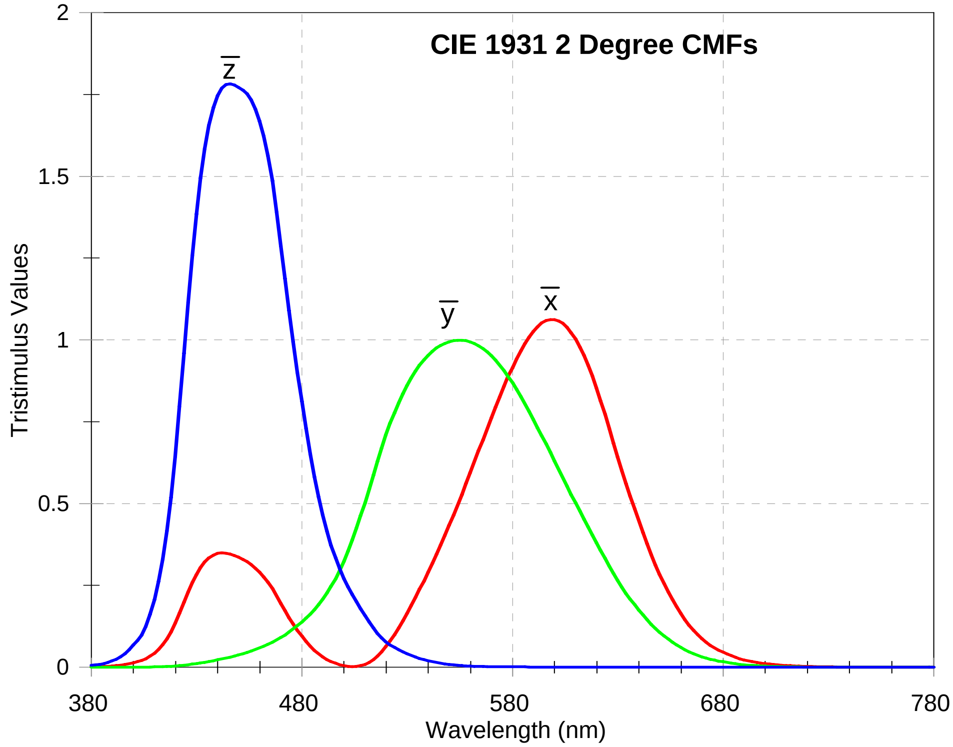

Figure 6. The CIE 1931 standard color-matching functions.

The color matching functions enable the perceived color of any color stimulus, such as light sources or the primary colors of any electronic display, to be described in a standard manner on a reference space known as a chromaticity diagram. This is achieved by weighting the spectra of each source or color primary by each of the color matching functions, integrating these weighted spectra over the visible spectrum and normalizing the resulting values to yield a set of chromaticity coordinates which locate the color in a two-dimensional chromaticity diagram.[1] A single color stimulus such as a light source is represented by a single point on a chromaticity diagram while a color display will contain a point for each color primary used, typically 3 points for the R, G and B color primaries. Figure 7 shows the original CIE 1931 chromaticity diagram.[1,2,3,4]

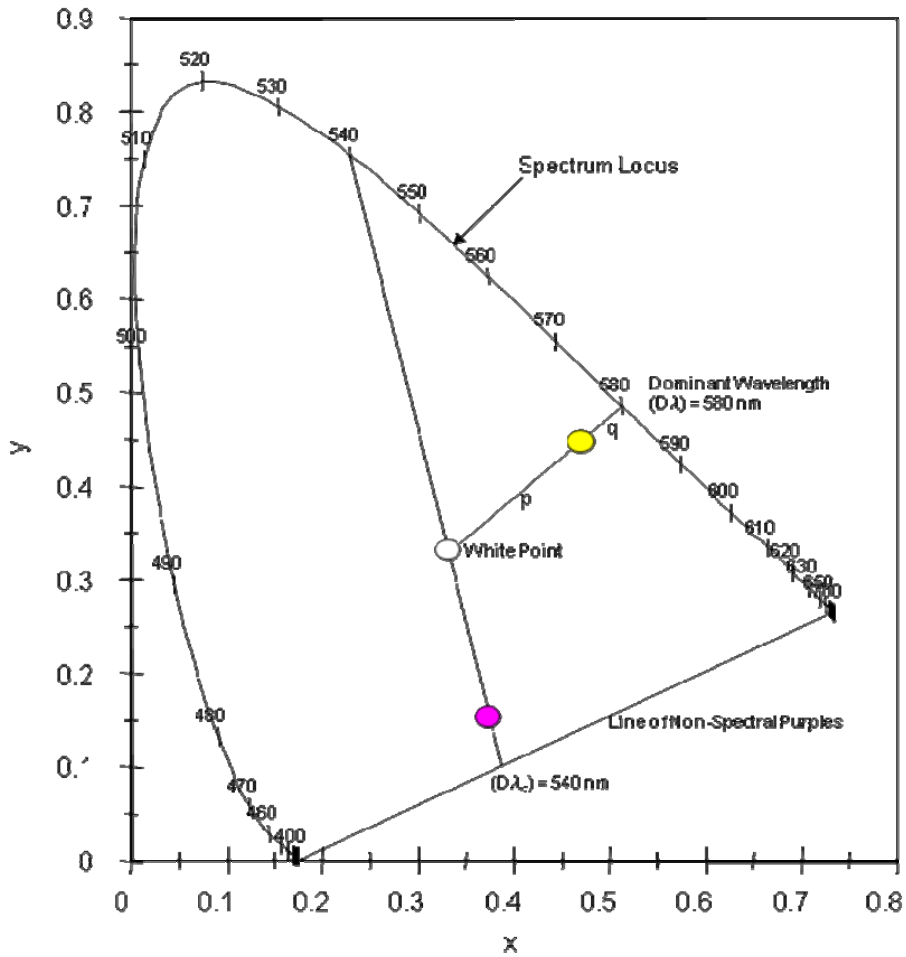

Figure 7. The CIE 1931 chromaticity diagram.

The horseshoe-shaped space depicted in Figure 7 represents the full range of wavelengths corresponding to colors visible to the HVS. All colors discernable by the HVS lie either on or within the boundaries of this horseshoe-shaped area, which is often designated as the MacAdam Limits and may be considered the color gamut of the HVS.[1] The points on the border of the horseshoe, known as the spectrum locus, are the chromaticity coordinates (xy values) corresponding to wavelengths in the visible light range for human observers which is from 380 nm(blue) to 780 nm (red). . These points are known as dominant wavelengths. The white point, which is a point at which the HVS perceives the color "white," lies near the center of the closed

area. The distance of a color from the white point toward the spectrum locus (pure spectral colors) provides an estimate of the purity or saturation of a color. The straight line closing the horseshoe from below, between the spectral extremes at the long (780 nm) and short (380 nm) wavelengths, is known as the line of non-spectral purples. Visible light containing light of a plurality of spectra lies inside the gamut. The uses of a chromaticity diagram will be illustrated in subsequent sections.

The two-dimensional "color gamut" of a display specifies the area envelope of colors or chromaticities that can be generated on the display independent of constraints imposed by the maximum and minimum luminance levels of the color primaries or the number of discrete intensity levels which can be addressed for each primary. The two-dimensional color gamut is typically described as the area bounded by display primaries in a reference chromaticity coordinate system. Various standards exist which specify the chromaticity coordinates for the color primaries, and resulting color gamuts, of displays used in television, computer workstations, graphics displays and for the proper reproduction of color content from the Internet[5]. One prominent and important specification for display color primaries is that designated as recommendation (Rec.) 709 for high-definition television (HDTV) by the International Telecommunications Union (ITU) and which also provides the basis for the sRGB color primary specification for computer graphics and color internet content.[5] Figure 8 shows the coordinates of the ITU Rec. 709/sRGB display color primaries plotted on a CIE 1976 UCS chromaticity diagram.[1,6] The chromaticity coordinates of the original National Television Systems Committee (NTSC) color standard for television,[5] the chromaticity coordinates of the current European Broadcast Union (EBU) television standard[5] and the color range for natural objects and surfaces (indicated as the gamut of typical real-world colors)[7] are also plotted for

comparison. The color gamuts for the sets of standardized color display primaries described in Figure 8 are indicated by the triangular areas bounded by the chromaticity coordinates of the respective RGB color primaries. For the purposes of color display specification, the use of the CIE 1976 UCS chromaticity diagram is generally preferred since it provides a more perceptually uniform spacing between color points than previous chromaticity diagrams such as the CIE 1931 chromaticity diagram or the CIE 1960 UCS chromaticity diagram.[1] The two-dimensional color gamut is a useful metric for the outer limits of display color performance in that the display is capable of producing any color point either on or within the bounded area, but the restrictions arising from the limited dynamic luminance range of the primaries and the quantization of that range are absent. Notice that none of the display color gamuts plotted in Figure 8 fully encompass the gamut of real-world object colors.

In order to synthesize a full range of colors, a display must contain at least three color primaries with a distribution of wavelengths in the red (R), green (G), and blue (B) regions of the visible spectrum. While almost all full-color displays utilize a set of R, G, and B color primaries, some displays employ more than three primaries to achieve specific performance objectives such as an extended range of colors or the matching of display colors to some other color media. This is discussed in greater detail below. The basic idea is that increasing the number of primary colors in a display also increases the range of secondary colors that can be produced by those primaries. When applied to some display technologies, the multi-primary approach can also increase the luminous efficiency of the display resulting in brighter displays for the same display system power. However, achieving improved color performance and enhanced efficiency through the utilization of great than three color primaries requires careful display system design as well as the utilization of optimized methods for color data transformation and color

management. Performance and implementation issues specific to multi-primary color displays will be discussed further in subsequent sections.

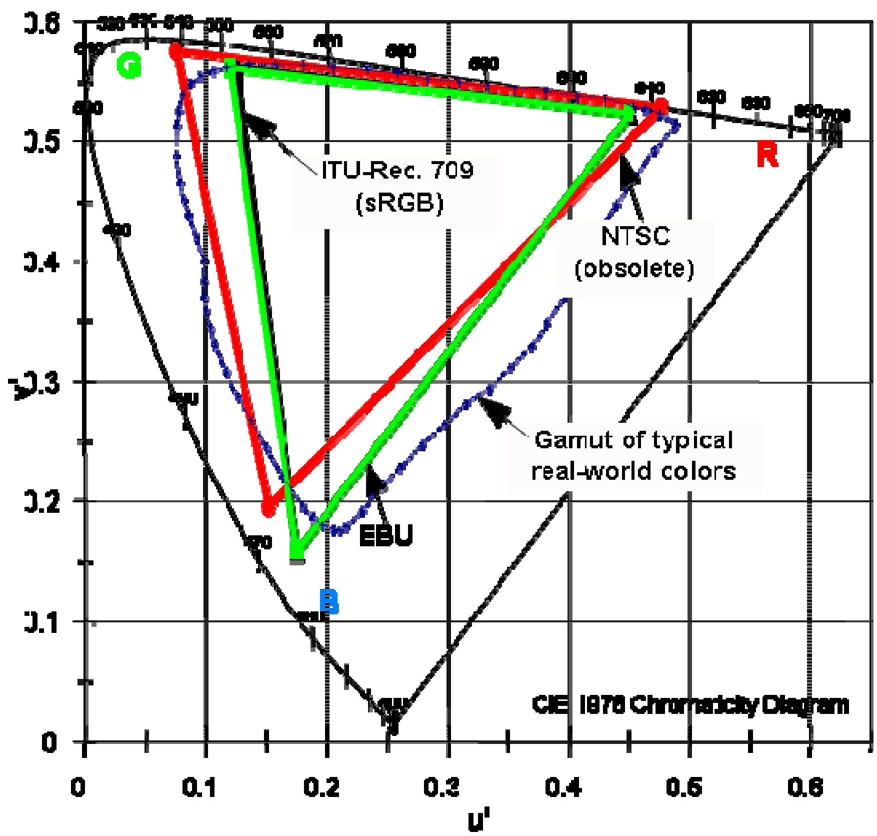

Figure 8. Color primaries for ITU-Rec. 709/sRGB, NTSC and EBU standards plotted on a CIE 1976 UCS chromaticity diagram. Gamut of typical real-world colors is plotted for comparison.

3. *The Principle (and Problem) of Metamerism*

The structure and function of human color vision makes the principle of metamerism possible, in which different spectral power distributions can result in equivalent color sensations.[1,3,4,8] Metameric colors are color stimuli of identical tristimulus values but different spectral composition. Under appropriate viewing conditions, they appear identical to the average observer. The principle of metamerism and the laws governing color matching form the basis of

the CIE system of colorimetry,[1,2,3] which serves not only as a method of color description, but also as a method for predicting visual matches of additive mixtures of colored luminous sources as described above. The importance of these concepts cannot be overemphasized as they constitute the foundation of electronic color imaging.

Metamerism can also be a problem, as each human perceives colors in a slightly different way.[8] The CIE colorimetric system was developed based on the responses of a number of people, but that system represents the "average CIE observer." In real life, however, typically no one person exactly matches that "average." In other words, any given individual does not perceive colors in precisely the same way as the CIE standard observer predicts. This means that if you look at an image, and I look at that same image, you and I will perceive slightly different colors. For one thing, there is a strong variation in color perception with age. As people age, parts of the eye yellow and absorb short wavelength light at a higher rate. This affects how an older person sees colors relative to a younger person.

Metamerism also poses a special problem for multi-primary displays and must be managed to achieve stable, reliable perception of color images for all observers. The problem arises precisely because there is more than one way to achieve a given color mixture.[8] Even though it is possible to get the same colorimetric match, the underlying spectra will be different and therefore most people will see slightly different colors. If there are only three primary colors in a display, there is only one way to make a secondary color of a specific chromaticity and all color mixtures for that display are said to be isomeric. Anywhere that color appears on the display, it will look the same because the same primary wavelengths are used. However, where there are more than three primaries, different combinations of primaries may be used to achieve colorimetrically equivalent mixture colors (i.e. they plot to the same point on a chromaticity

diagram)—but those different color combinations will result in most viewers perceiving slight different colors where the designer of the image meant there to be a single, uniform color. Recent research efforts have recognized this issue and have developed approaches to minimize or eliminate the effects of on-screen metamerism in multi-primary displays.[8] The approach to multi-primary display color transformation pioneered by Genoa Color Technologies, LTD. and described in the '152 patent, which maps three-primary RGB input data into a multi-primary representation, is unique in that it both maximizes color primary utilization and precludes the occurrence of on-screen metamerism.

4. ***Color Synthesis***

The concept of additive mixtures of chromatic luminous sources is perhaps the most basic operating principle enabling the development of full-color electronic displays. In principle, the simplest form of additivity is obtained by direct superposition of three differently colored beams of light or colored images. However, two other characteristics of the HVS offer great flexibility in techniques for synthesizing color. Since the HVS is quite limited in both the spatial and temporal resolution of visual input, spatial or temporal patterns composed of three (or more) appropriately selected primary colors are sufficient for producing the full range of colors when the spatial or temporal frequencies of the patterns exceed the respective resolution limits.[2,3] Spatial resolution of the HVS is basically limited by the optics of the eye and the fineness of the retinal mosaic of cone receptor elements, while temporal resolution is limited by the finite temporal bandwidth of the retinal photoreceptors and other neuronal elements. These limits in spatial and temporal resolution, or more precisely, the fact that integration occurs beyond these limits, permit the phenomena of spatial-additive and temporal-additive color synthesis to occur.

Several approaches to color synthesis have traditionally been employed for electronic displays. The most successful of these conform to the principles of additive color mixture and include optical superposition, spatial synthesis and temporal synthesis.[3] Direct optical superposition of three primary color images is commonly used in projection display systems. However, while optical superposition is an effective method of color synthesis for projection systems it is not readily amenable to most direct-view color display technologies.

Spatial color synthesis has by far been the most successful method and is the foundation of modern color display technology. The basis of spatial synthesis lies in the fact that spatially separate image points of different color, if small enough and viewed from a sufficient distance, cannot be individually resolved by the human visual system and integrate spatially to produce a color which is equivalent to a mixture of the image points within a small projected region of the retina. The mixture color produced by spatial synthesis is effectively the same as that produced by direct superposition. The three most successful electronic color display devices available, the shadow-mask color CRT, the color liquid crystal display (LCD) and the color plasma display (PDP), conform to this principle. Figure 9 illustrates the principle of spatial color synthesis in CRT and LCD display technologies.

Shadow-mask Color CRT Active-matrix Addressed Color LCD

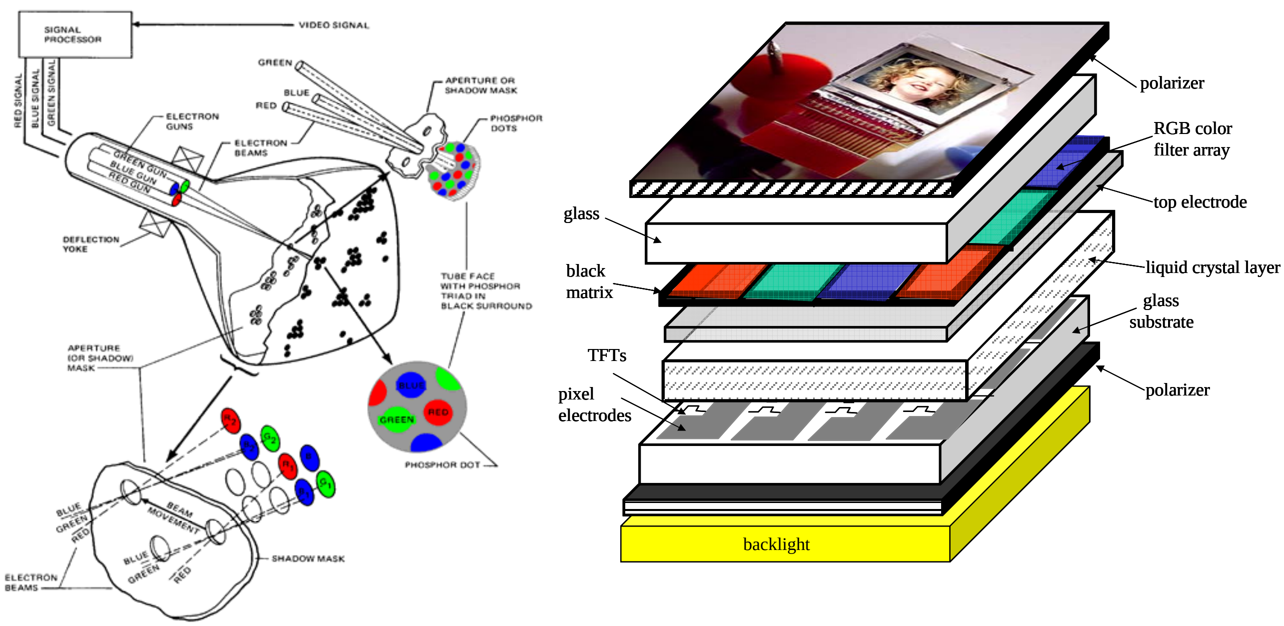

Figure 9. Illustration of the principle of spatial color synthesis in color CRTs and color LCDs.

Although spatial-additive color synthesis has been extremely successful, the method has several limitations that reduce the efficacy of the approach. First is an obvious sacrifice of potential display resolution: the use of available spatial area for color synthesis reduces the spatial imaging potential of the display. Second is a reduction in space-average luminance since each primary color (e.g., R, G, and B regions in Figure 6) composing a full-color picture element (pixel) occupies only a fraction of the available display surface. A final limiting factor is the spatial fixed-pattern noise produced by the mosaic of primary color sub-pixels and particularly the low-luminance blue sub-pixel elements. It is noteworthy that both the spatial resolution and space-average luminance of a display are generally reduced as the number of primary colors used is increased.

Temporal color synthesis occurs because the visual system will integrate rapidly alternating chromatic stimuli to produce a color that is a mixture of the time-varying components.[4] Visual displays that utilize temporal color synthesis are typified by field-sequential projection TVs and data projectors which utilize a mechanically rotating color wheel (generally containing R, G and B color filters) in front of a broad-spectrum light source which is imaged on a reflective image-forming device such as a digital light processing chip (DLP—a micro-electro-mechanical system or MEMS device consisting of a two-dimensional array of micro-mirrors on a silicon substrate) and then relayed through a projection lens onto screen. A number of variations on this basic approach are on the market today, including those using color wheels with 5 (RGB + yellow and cyan) or 6 (RGB + yellow, cyan and magenta) primary color segments and recently introduced field-sequential color projection systems which utilize sequentially activated RGB LED illuminators instead of a broad-spectrum light source in conjunction with a rotating color wheel. Figure 10 illustrates the basic operating principle of a field-sequential color projection system utilizing a DLP image-forming device.

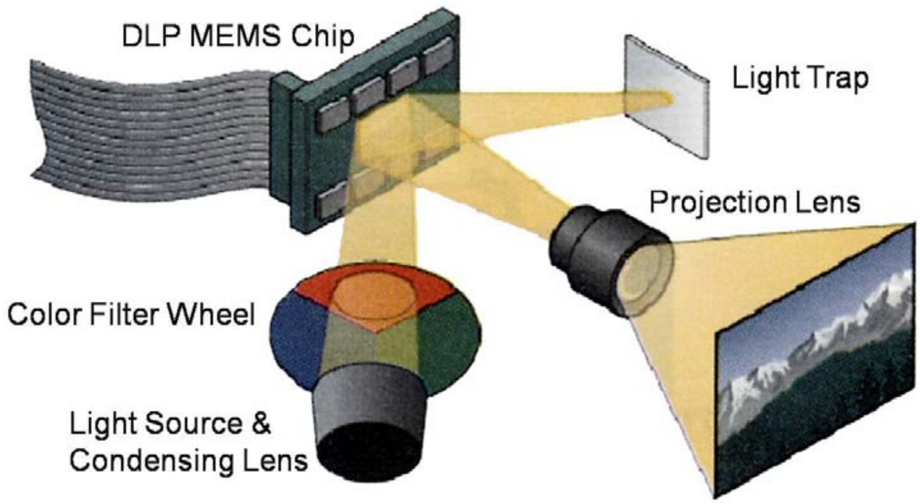

Figure 10. Illustration of the principle of temporal color synthesis in field-sequential color DLP projection systems.

The DLP chip is also known as a digital micro-mirror device or DMD and belongs to a class of image-forming devices known as spatial light modulators (SLMs). SLMs are devices which impose some form of spatially-varying modulation on a beam of light to create a two-dimensional light pattern or image. The modulation may occur in the intensity, spectrum, polarization or angular light distribution of the beam. In display applications, SLMs function as the image-forming element of the display system.

Temporal color synthesis, or field-sequential color, avoids the loss of spatial resolution that is inherent to spatial synthesis and does not produce fixed-pattern noise. However, several important limitations of temporal color synthesis constrain the efficacy of field-sequential color displays. First, although the field-sequential approach produces effective additive color mixtures, residual luminance differences between the time-varying components can produce

observable luminance flicker for temporal frequencies at or above those at which effective chromatic integration has taken place. A more difficult limitation results from relative movement between the displayed image and the viewer's retina, whether the motion arises from the image or from the viewer's head and eye movements. In either case the time-varying color components are no longer imaged on the same retinal region and the observer experiences what has come to be known as "color break-up" or "the rainbow effect." Avoiding color break-up for RGB field-sequential displays in the presence of rapid eye movements requires color field rates well in excess of those needed to eliminate flicker and can easily exceed 1000 Hz when the display luminance and contrast are high. The current "de facto" standard for sequential color field rates is in the range of 360-480 fields-per-second. These high field rates impose severe bandwidth requirements on field-sequential displays and make the temporal isolation of primary color image fields difficult. Finally, field-sequential color generally results in a reduction in time-average luminance since each primary color field (e.g., R, G and B color filter time windows in Figure 10) composing a full-color image frame occupies only a fraction of the available image frame time.

It should be noted that in DLP-based multi-primary projection displays with optimized optical design and a color transformation/color management system which maximizes utilization of all primary colors that color break-up can be dramatically reduced[9,10] and display luminous efficiency can be increased over that obtainable with a three-primary RGB approach.[10] These advances are explicit in the teachings and published research of Genoa Color Technologies, LTD. and are embodied in the color projection display system approach described in Genoa's '152 patent.

5. ***The Display Technology Landscape Today***

Over the past twenty-five years a diversity of display technologies has evolved to support a wide range of applications. On the consumer side these include television (TV) receivers, computer monitors, cell phones, PDAs, automobile dashboards, portable navigation devices and extremely large displays for electronic signs and billboards. Among the many military and aerospace applications of advanced display technology are aircraft instruments, shipboard navigation and control systems, ground vehicle electronics, spacecraft displays, command & control systems and tactical displays for soldiers in the battlefield. In all application categories expectations for display performance have grown at a rapid pace, driving the accelerated development of core display technologies along with supporting control algorithms and image processing methodology.

In the recent past, consumers and system developers had only very limited options when selecting a display. Few technology alternatives to the CRT existed. Although the venerable CRT may still be found in a significant number of display applications, this device has undergone steady declines in installations and market share as newer, more compact and more efficient display technologies have come to the forefront. Today we are confronted with a remarkable proliferation of display technologies. Figure 11 illustrates the range of currently available display technologies, most of which are capable of generating full-color images.

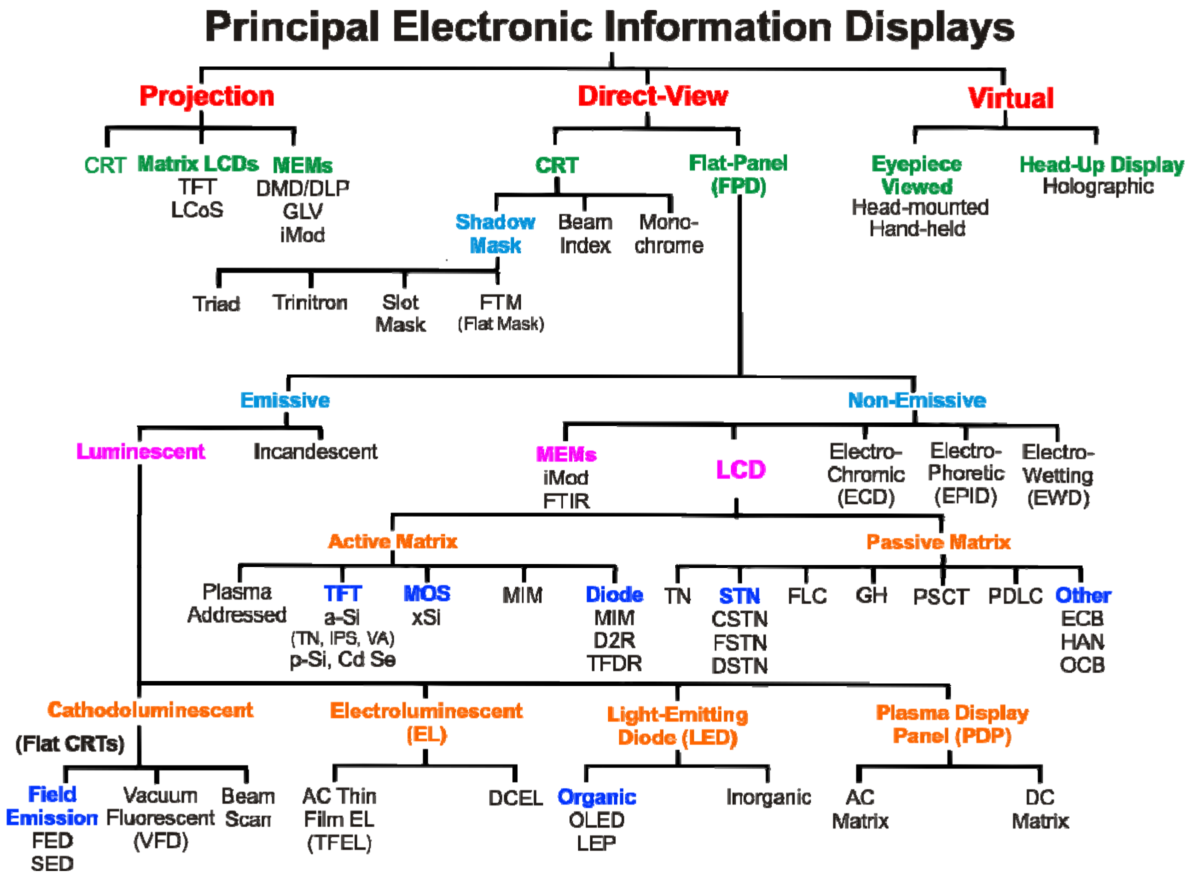

Figure 4. Hierarchical organization of currently available display technologies.

The hierarchical structure provided in Figure 11 organizes display technology according to viewing mode (projection, direct-view and virtual) and whether the technology intrinsically generates light (emissive) or modulates light from a separate external or internal source (non-emissive). Regardless of the display technology employed, the common emphasis in virtually all application areas is on improved display image quality and lower display cost. Desired image quality improvements for all displays consist of enhancements in contrast, brightness and resolution. Although color displays are not required for all applications, color has become so ubiquitous that it has almost become a de facto requirement for both system developers and display end users. Moreover, display end users are growing ever more knowledgeable about color, leading to expectations for improved color performance in the form of larger display color

gamuts, enhanced color saturation and more accurate color rendering for all applications. This has provided the impetus for the development of multi-primary color display technology along with concomitant advancements in methodology and algorithms for display color management. Genoa Color Technologies, LTD. has been a pioneer in developing and demonstrating the first cost-effective, comprehensive multi-primary projection display system with demonstrated performance enhancement.

6. ***Displays Having More than Three Primary Colors***

Over the past one or two decades, there have been two major technology trends for expanding the display color gamut: the development and use of more saturated RGB primaries; and the development of displays with more than three primaries.

In the case of improved RGB primaries, large-area emissive displays such as CRTs and PDPs must rely on the development of improved phosphors with narrower spectral emissions and/or the use of auxiliary color filters to limit the spectral passband. For direct-view color LCD panels and projection displays using either LCD or MEMs-based SLMs as image sources, the preferred approach is to deploy narrow-band illumination sources such as LEDs or semiconductor laser sources. While the percentage of the NTSC color gamut occupied by the ITU-Rec. 709 or EBU color primaries is approximately 75% (see Figure 8), the coupling of LED backlights to large active-matrix LCD panels has already achieved color gamuts in excess of 105% of the NTSC specification. Color television receivers which utilize LED illumination and possess expanded color gamuts are already commercially available from Sony and Samsung. Moreover, compared to the fluorescent backlights commonly used for direct-view LCDs and the metal-halide arc lamps typically used in projection display systems, LED and laser illumination

sources enable precisely selectable white points without sacrificing useable quantization levels and provide for more accurate, stable and spatially homogeneous control of color.

It is noteworthy that the color performance advantages offered by improved RGB primaries require at most only simple remapping of the input data and therefore require only minimal additional processing resources. Figure 12 contains the plotted gamuts of Figure 8 with the addition of a display color gamut enabled by the use of RGB primaries generated by solid-state lasers. Notice that the size of the gamut is increased considerably with the laser primaries and now encompasses virtually the entire gamut of real-world colors with the exception of a very small region along the G-B axis. Very similar results may be obtained with available RGB LED sources of similar center wavelengths.

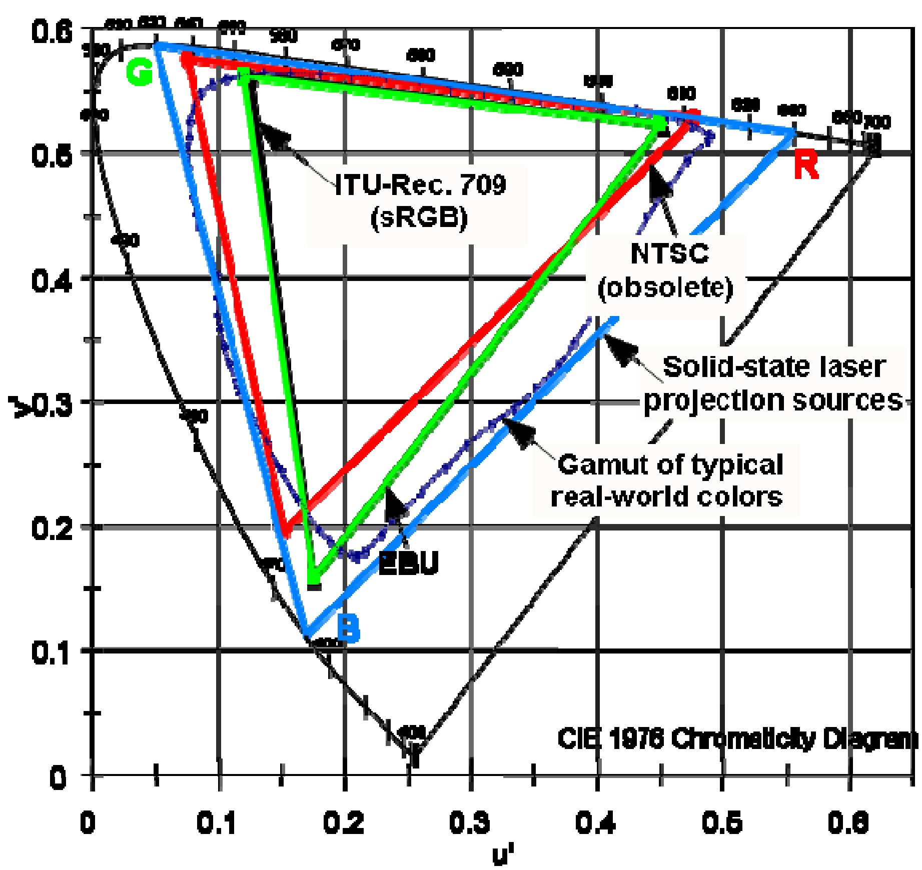

Figure 12. Color primaries for ITU-Rec. 709/sRGB, NTSC and EBU standards plotted on a CIE 1976 UCS chromaticity diagram. Gamuts of optimized set of solid-state laser primaries and typical real-world colors are plotted for comparison.

The other approach to enhancing display color gamuts is to develop displays which utilize more than three primary colors. To date multi-primary displays with 4, 5 and 6 primary colors have been developed for both direct-view and projection configurations and using technologies ranging from LCDs and LEDs for direct-view applications and DLP/DMD and liquid-crystal-on-silicon (LCoS) image sources for projection applications.

Multi-primary projection display systems using single DLP/DMD or LCoS image sources and field-sequential color synthesis provided by a segmented color wheel are currently on the market in both 5- (Samsung) and 6-primary color (Mitsubishi) configurations. All of these multi-primary (>3 primary colors) approaches for achieving an expanded color gamut have demonstrated performance in excess of current ITU-Rec. 709/sRGB or EBU standards, and some have exceeded the gamut of the original NTSC color primary specification. Figure 13 shows the color gamut of a DLP-based projection display system using 5-primary colors along with the sRGB standard color gamut and the distribution of real-world surface colors plotted on a CIE 1931 chromaticity diagram.[10]

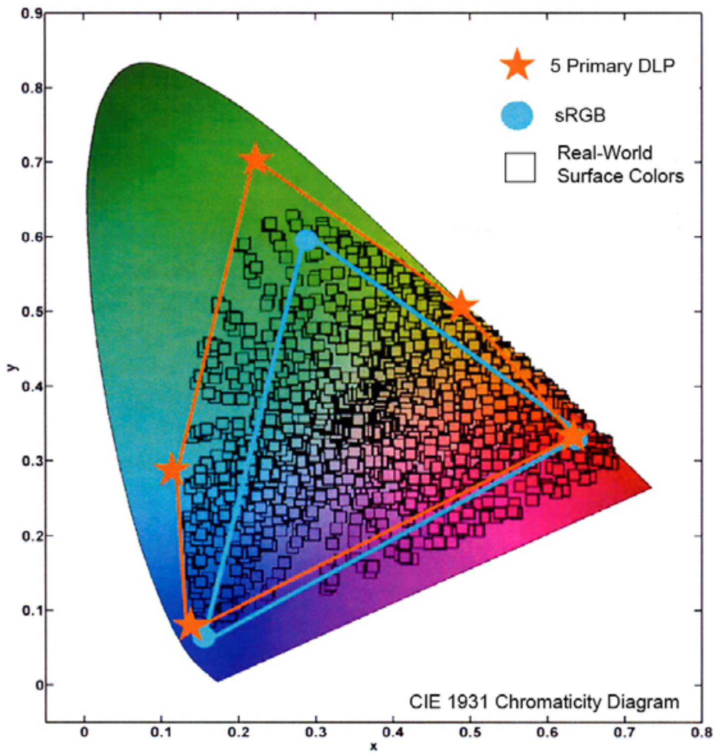

Figure 5. Color gamut for a 5-primary DLP-based projection display as compared to the gamut for the sRGB standard primaries and sample distribution of real-world surface colors plotted on a CIE 1931 chromaticity diagram.[10]

B. <u>Multi-primary Display Technology at Issue in the '152 Patent.</u>

In accord with recent trends in electronic display development noted above, the principal objectives of the inventors of Genoa's '152 Patent were to develop technology and methods for expanding the color gamut and enhancing the color imaging performance of electronic display systems. They recognized that the color rendering performance of displays which synthesized a full color gamut with the typical, minimal set of three primary colors was limited by the spectral encoding and color processing of the HVS and sought means to enhance the effective color performance of displays. The technical approach adopted by the inventors was the integration of multi-primary (> 3 primary display colors) color display technology with efficient and novel methods of color management. Although the inventors recognized the many alternative

approaches to multi-primary color display technology, they determined that the most cost-effective and efficient approach at the time of their invention was through the use of field-sequential color synthesis employing a multi-primary color wheel for color separation and a single, spatial light modulator (SLM) for image formation. The focus of their innovation in the '152 Patent was on the <u>integration and co-optimization</u> of field-sequential, multi-primary color display technology with an efficient methodology for multi-primary color mapping and color system management.

Although the color mapping from "standard" inputs consisting of color image data for three primary colors (e.g., RGB) or triplets of processed color signals (e.g., YCC, YUV, YC_bC_r, or XYZ) to a system of more than three primaries is required for a multi-primary color display system, the derivation of an optimal and efficient methodology for performing the mapping or transformation is <u>non-trivial and not obvious</u>. The previous sections have shown that for typical color display systems employing three primary colors, the display color gamut is represented as a triangle in the chromaticity plane. In this triangular color space any selected color either on or within the gamut boundary may be synthesized by a set of fixed intensity ratios between the three primary colors. Such a linear system is said to be determined, and all selected colors of a given chromaticity and intensity are isomeric in that they are composed of the same spectral power distribution. In a three-primary color system the standard methodology of using 3 x 3 color characterization and transformation matrices yields a stable, determined system of equations to accomplish color primary transformations as well as other color management tasks. However, for a multi-primary color display any linear system for color characterization and transformation is overdetermined in that multiple solutions exist such that some subset of selected colors can be achieved with alternative combinations of the >3 primary colors. Recall

from the discussion in a previous section that selected colors which achieve a colorimetric match with alternative combinations of the >3 primary colors have different spectral power distributions and are said to be metameric. Unfortunately, colorimetric matches which are also metameric are fragile in that they are seen as identical to the CIE "Standard Observer," which is essentially a statistical average color sensitivity function, but often appear different to a real observer whose sensitivity functions typically depart from those of the "Standard Observer." The impact of an overdetermined linear system for the colorimetry of multi-primary color displays and the associated issues regarding selection of on-screen metameric colors make the typical, standard matrix methods for color characterization and color transformation unreliable and impractical when applied directly to color management for multi-primary color display systems.

Alternative solutions to multi-primary color management problems have been developed and utilize various means to constrain the solution set. Typically, the multi-primary color space is considered as a polygon in the chromaticity plane with *N* sides and *N* vertices or angles corresponding to the *N* color primaries of the system. This geometric construction of color space can generally be decomposed into *N*-2 non-overlapping triangles with the vertices of each triangle defined by a subset of three of the >3 color primaries of the system. Once this partitioning of the multi-primary color space is accomplished, the solution to resolving a selected color into a combination of primaries within the multi-primary system becomes one of finding the triangle containing the selected color and utilizing the well-established 3 x 3 matrix methods by considering only the three primaries which define the color triangle containing the selected color. Variations of this general approach are possible and have been developed. While this general approach yields colorimetrically valid solutions, they are decidedly non-optimal in that

they permit the synthesis of selected colors by using only a subset (typically a maximum of three) of the available system primaries for each selected color or image pixel.

Figure 14 illustrates the decomposition of a 6-primary color space into a set of 4 (*N-2*) non-overlapping triangles. The target color sample point, (x_0,y_0), is located in the triangle bounded by the primary subset P_1, P_2 and P_6. Once the triangle containing a sample color is located, the sample color may be unambiguously resolved into appropriate combinations of the primaries defining that triangle via well-established 3 x 3 matrix methods. However, it should be reiterated that such methods, while colorimetrically accurate, provide poor utilization of the full set of available display system primaries and sub-optimal system luminous efficiency. It should be apparent that alternative sets of non-overlapping triangles may be formed from the 6 primary color points.

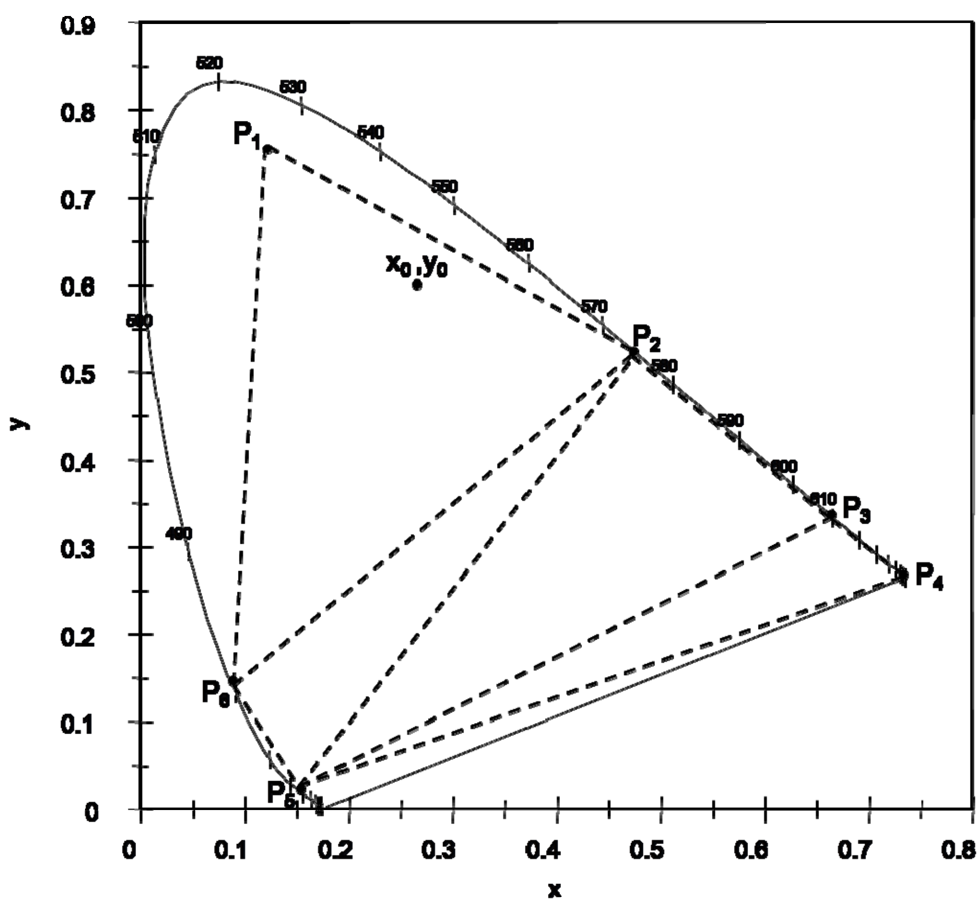

Figure 6. Geometric schema of typical approach to multi-primary color transformation.

Genoa recognized that such solutions to multi-primary display color management were not optimal and limited the color imaging potential of multi-primary displays. They sought and devised a novel and comprehensive methodology for transforming and mapping color image input data specified in terms of three primary colors (e.g., RGB) or triplets of processed color signals (e.g., YCC, YUV, YC_bC_r, or XYZ) to a multi-primary representation with > 3 primary colors which enables maximized usage of all available system primaries. While selected colors of maximal excitation purity which lie on the multi-primary gamut boundary are synthesized with a maximum of two primary colors, as they must be in any correct color transformation, in their color transformation and mapping system selected colors which lie inside the gamut boundary of the multi-primary color space are generally synthesized using all of the available color system primaries rather than subsets of the primaries.

Figure 15 illustrates one of the preferred embodiments for RGB to multi-primary color mapping described in Genoa's '152 patent. In order to highlight the difference in technical approach, the example utilizes the same set of 6 primary colors and target color sample point as in Figure 14. In this embodiment a neutral point (X_w, Y_w) is defined which is composed of a predetermined combination of all 6 of the system primaries. This enables the multi-primary display color space to be decomposed into a set of triangles which share a common vertex at (X_w, Y_w). As in the previous example, the triangle containing the sample color is located. Once the triangle containing the sample color point is located, the sample color may be unambiguously resolved into appropriate combinations of two of the system primaries and the common vertex point (X_w, Y_w). Recalling that the common vertex is a neutral point (X_w, Y_w) defined by a

combination of all of the color primaries of the system, this approach provides for colorimetric accuracy and ensures that all of the display system primaries are maximally utilized. It should be noted that for reproduced colors of maximal excitation purity, which lie on the multi-primary gamut boundary and are synthesized with a maximum of two primary colors, the relative intensity values of the remaining system primaries will assume a value of zero. Reproduced colors of near-maximum purity may also result in some multi-primary components with intensity coefficients of zero value.

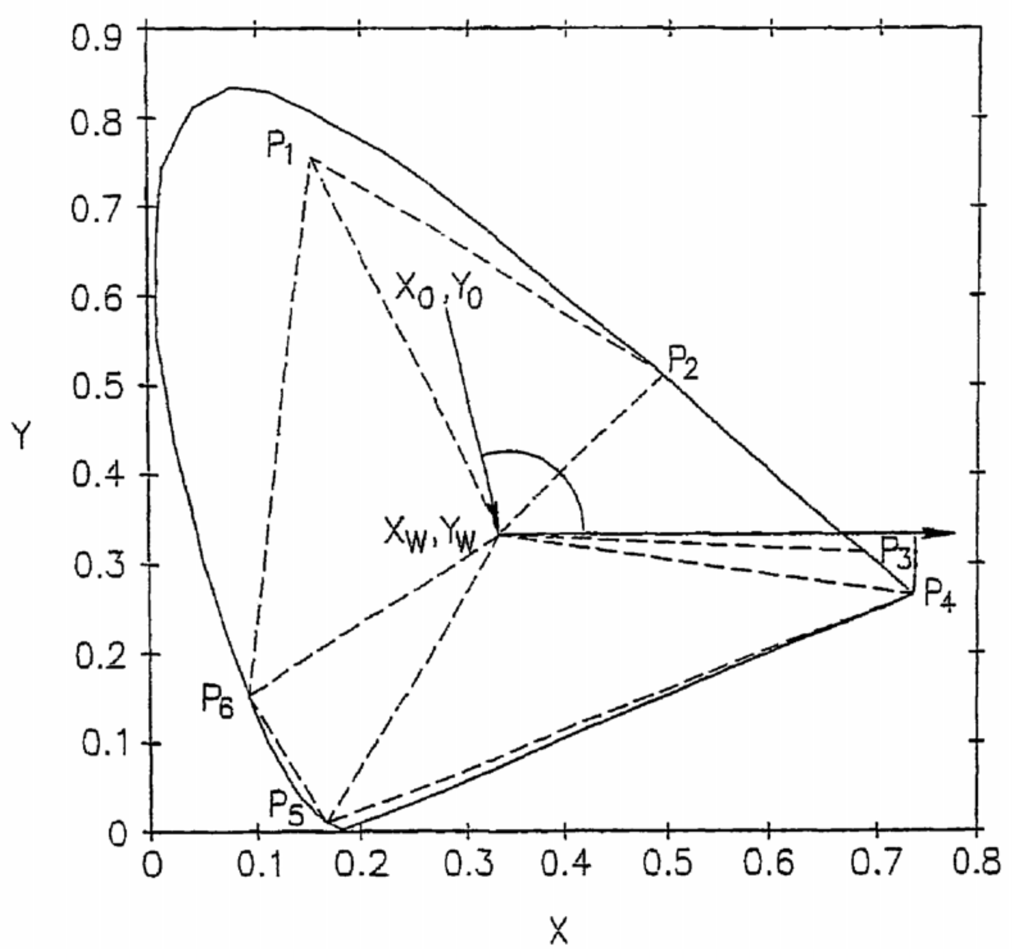

Figure 7. Geometric schema of one preferred embodiment for optimized multi-primary color transformation from the '152 patent (Figure 6A from the '152 patent).

Genoa further recognized that an optimized color transformation and mapping system for multi-primary color displays enabled better integration with the multi-primary display technology and provided opportunities for the co-optimization of the color management algorithms with the display system hardware. In their ‘152 Patent the inventors focused on the coupling of their novel methods for multi-primary color management with a multi-primary color display technology based on field-sequential color synthesis. They determined that the most cost-effective and efficient approach at the time of their invention was through the use of field-sequential color synthesis employing a multi-primary color wheel for color separation and a single, SLM for image formation. The ‘152 Patent provides thorough and richly detailed teaching of their novel and comprehensive methodology for color management of multi-primary color displays and further teaches the co-optimization of field-sequential multi-primary color displays utilizing a multi-primary color wheel for color separation and a single, SLM for image formation. By co-optimizing the multi-primary display system hardware with the multi-primary color management algorithms and associated control systems, the inventors of the ‘152 Patent reveal that a multi-primary color display system with a larger color gamut, improved color accuracy, enhanced luminance throughput, reduced propensity to flicker and control of on-screen metameric colors can be achieved. These teachings are reflected in the claims of the ‘152 Patent.

VI. IMPLICATIONS FOR CLAIM CONSTRUCTION FOR THE ‘152 PATENT

In this declaration I have attempted to provide sufficient background information on the basics of color vision, color science and color display technology to facilitate interpretation of the core technical issues in Genoa’s ‘152 patent. Clearly, the rationale and focus of the ‘152 patent is on optimal methodology and systems integration for multi-primary color display technology. The ‘152 patent departs from generalized technical approaches for more traditional

color displays utilizing three color primaries and goes beyond standard methods of color image generation and color management. As such, claim construction for the '152 patent must reflect this clear focus on multi-primary display technology in both the definition of claim terms and the meaningful and correct construction of the claims.

Exhibit B of this declaration provides Plaintiff's proposed claim construction for U.S. Patent No. 7,113,152 which contains my contributions and fully reflects my opinions on the proper meaning of the claims. The proposed claim construction in Exhibit B is presented in tabular form with three columns containing, from left to right: (1) the elements of each of the claims asserted by the Plaintiff; (2) the claim construction proposed by the Plaintiff; and (3) the support relied on by the Plaintiff for its proposed claim construction. The specific terms construed in column 2 are those claim elements or portions thereof that are shown in bold type in column 1. In the third column, the Plaintiff has identified the specific line and page references of the specification to which it wishes to draw the Court's attention, as well as applicable portions, if any, of the prosecution history.

I participated in the drafting of Section III of Plaintiff's Claim Construction Brief, entitled "Overview of the Relevant Technology and the '152 Patent." I incorporate said "Overview" by reference in this declaration. In my professional opinion, every statement therein is factually correct.

VII. CERTIFICATION

The teachings and opinions contained in this declaration are my own and are independent of both my compensation as an expert witness for the Plaintiff and the outcome of the case.

Signed under the pains and penalties of perjury this 24th day of April, 2008.

Louis D. Silverstein, Ph.D.

VCD Sciences, Inc.

April 22, 2008.

VIII. REFERENCES

1. Wyszecki, G., and Stiles, W. S. (1982). *Color Science: Concepts and Methods, Quantitative Data and Formulae, 2nd Edition*. New York: John Wiley & Sons, Inc.

2. Silverstein, L. D. (2004). Color in Electronic Displays. *Society for Information Display Seminar Lecture Notes, Volume 1*, M-13/1-M13/63.

3. Wandell, B. A., and Silverstein, L. D. (2003). Digital color reproduction. In S. Shevell (Ed.), *The Science of Color, 2nd Edition*. Washington, D. C.: Optical Society of America, 281-316.

4. Hunt, R. W. G. (2004). *The Reproduction of Colour, 6th Edition*. West Sussex, England: John Wiley & Sons Ltd.

5. Poynton, C. (2003). *Digital Video and HDTV: Algorithms and Interfaces.* San Francisco: Morgan Kaufmann Publishers.

6. Commission Internationale de L'Eclairage (CIE). (1978). *Recommendations on Uniform Color Spaces - Color-Difference Equations, Psychometric Color Terms.* Supplement 2 to CIE Publication 15.

7. Pointer, M. R. (1980). The gamut of real surface colors. *Color Research & Application*, 5, 1, 25-43.

8. Brill, M. H. and Larimer, J. (2005). Avoiding on-screen metamerism in n-primary displays. *Journal of the Society for Information Display*, 13, 6, 509-516.

9. Eliav, D., Langendijk, E. H. A., Swinkels, S., and Baruchi, I. (2005). Suppression of color breakup in color-sequential multi-primary displays. *Society for Information Digest of Technical Papers, Volume XXXVI, Book II*, 1510-1513.

10. de Vaan, A. J. S. M. (2007). Competing display technologies for the best image performance. *Journal of the Society for Information Display*, 15, 9, 657-666.

Exhibit A

Curriculum Vitae of Louis D. Silverstein

Louis D. Silverstein

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Home: (480) 391-2610
E-Mail: lou-s@vcdsci.com

PERSONAL DATA: Birthdate: November 28, 1950
Marital Status: Married, no children

PROFESSIONAL OBJECTIVE:

Research and development emphasizing education and skills in Applied Visual Science, Color Science, Display Technology, Physical Optics and Liquid Crystal Technology, Sensory Psychophysics, Human Factors Engineering, Computer Science, and Psychophysiology. Seek interesting problems and areas of application.

EDUCATION:

University of Wisconsin - Madison, Wisconsin

National Institute of Health Postdoctoral Fellow - June 1977 to August 1979

University of Florida - Gainesville, Florida

Ph.D.	1977	Majors: Psychophysics, Perception and Vision Science
M.S.	1974	Minors: Computer Science and Biomedical Electronics
B.S.	1972	Major: Experimental Psychology

PROFESSIONAL AFFILIATIONS:

Fellow, The Society for Information Display
Member, The Optical Society of America
Member, The Inter-Society Color Council
Member, The Commission Internationale L'Eclairage (CIE)
Member, The Society of Imaging Science and Technology
Member, The Human Factors Society
Member, The Society for Psychophysiological Research

SPECIAL HONORS AND ACTIVITIES:

Society for Information Display – 2008 Recipient of the Otto Schade Prize for "his many contributions to the enhancement of display performance and image quality, including pioneering efforts in integrating display technology and color science."

Society for Information Display – 2005 Recipient of the Distinguished Paper Award for the paper "STColor: Hybrid Spatial-Temporal Color Synthesis For Enhanced Display Image Quality."

Inter-Society Color Council – 2004 Recipient of the MacBeth Award for "outstanding contributions to the science of color, achieved in color rendering through liquid crystal technology in electronic displays and image capture devices."

Society for Information Display – 2004 Recipient of the Special Recognition Award for"outstanding efforts in the conversion of commercial airplane flight decks from mechanical instruments to electronics color displays, while maintaining safety of flight under all lighting conditions."

Elected Fellow of the Society for Information Display, 1997 for "contributions to the design and evaluation of liquid crystal displays, including novel methods for display modeling and simulation."

The National Academy of Sciences/National Research Council - Appointed Member of Committee on Vision, July 1987 - July 1991 (Maximum Four-Year Term).

Honeywell Inc. - 1989 recipient of the Corporate Technical Achievement Award for liquid crystal display modeling and simulation.

The Human Factors Society - 1983 recipient of the Alexander C. Williams, Jr. Award for "outstanding human factors contributions to the development of a major, operational man-machine system."

The National Academy of Sciences/National Research Council - Committee on Human Factors - Member of technical working group on application principles for multi-color displays, April 1985.

The Commission Internationale L'Eclairage (CIE) - Member of the U.S. National Committee.

The Society for Information Display - Member of technical program committee, 1984 - present. Chairman of the Applied Vision/Human Factors Committee, 1987 - 1999.

The Society for Information Display – Member of the Awards Committee, 2005 – present.

The Society for Information Display – Representative to the Color Imaging Conference and liaison to the IS&T, 2006 – present.

The Society for Information Display - Technical Program Chairman for the 1991 SID International Symposium, Seminar and Exhibition. General Conference Chairman for the 1993 SID International Symposium, Seminar and Exhibition.

The Society for Information Display - Board of Directors, Chairman of Special Technology Committee on Applied Vision and Human Factors, 1988 - 1990.

The Society for Imaging Science and Technology - General Conference Chairman for the 1995 IS&T/SID Color Imaging Conference.

The Society of Automotive Engineers - Member of G-10 technical working group on human behavioral technology, 1985 - 1990.

National Institute of Health Postdoctoral Fellowship - Career Development Award (June 1977 - August 1979).

Corporate Technical Advisory Board, Dolby Canada Corporation (formerly Brightside Technologies), 2006 – present

Corporate Technical Advisory Board, Optiva Inc., 2002 – 2006.

Editorial Board, *Color Research and Application*

Editorial Board, *Displays*

Editorial Board, *Human Factors (1988-1993)*

Associate Editor, *Journal of the Society for Information Display (1991-1994)*

Associate Editor, World Scientific Publishing Co., *Information Display Series*

Reviewer, *Journal of the Optical Society of America A*

Patents - **Twenty-eight** awarded and **seven** pending in the areas of advanced display and imaging technology.

EXPERIENCE:

July 1990 to Present

Founder and Chief Scientist **-** VCD Sciences, Inc., Scottsdale, Arizona

VCD Sciences, Inc. is a scientific research and consulting firm with project specialization in the areas of applied vision, color science, and display technology. Current and past clients include: Apple, Inc.; Aurora Systems, Inc.; Dolby Laboratories; Colorado MicroDisplay, Inc.; dpiX (a Xerox Company);

Freescale Semiconductor, Inc.; Hewlett-Packard Laboratories; Hughes Aircraft - Ground Systems Group; Hughes Aircraft - Training Systems Group; Hughes-JVC Technology Company; Industrial Technology Research Institute (ITRI – Taiwan); Intel Corporation; InViso, Inc.; Iridigm Display Corporation; Motorola Flat-Panel Display Division; Motorola Phoenix Corporate Research Laboratories; Motorola Telematics Communications Group; NASA Ames Research Center; Novalux, Inc.; Optiva, Inc.; Philips Electronics; Qualcomm, Inc.; Rockwell Collins/Kaiser Electronics Group; Three-Five Systems, Inc.; Toppoly Optoelectronics Corporation; United Defense LLC; and Xerox Palo Alto Research Center.

1. ***September 1984 to July 1990***

Senior Research Fellow (January 1989 - July 1990) - Systems and Research Center, Honeywell Inc., Phoenix, Arizona.

Research Section Chief (July 1987 - December 1988) - Systems and Research Center, Honeywell Inc., Phoenix, Arizona.

Senior Staff Scientist (September 1986 - July 1987) - Corporate Technology Center, Sperry Corporation, Phoenix, Arizona.

Staff Scientist (September 1984 - September 1986) - Corporate Technology Center, Sperry Corporation, Phoenix, Arizona.

Responsibilities for research and application across a broad range of man-machine systems. Major areas of emphasis include the following: advanced visual display concepts; visual information processing; color perception; display symbology and format design; speech technology and applications; perceptual and cognitive factors influencing the design of user/computer interfaces; human performance measurement; operator task simulation; and experimental design/analysis. Specific projects involve computer-based visual displays and control systems, voice I/O for aircraft and space applications, color display information transfer, and human performance measurement in simulated task environments.

July 1983 to July 1984

Principal Scientist - General Physics Corporation, Atlanta, Georgia

Responsibility and participation in a broad range of human engineering research programs. Primary emphasis on the following research areas: advanced visual display concepts, performance assessment in high-fidelity simulation, perceptual and cognitive factors influencing the design of user/computer interfaces, and the measurement of operator workload.

Specific projects included: the assessment of communications-related workload in crews of transport category aircraft for the National Aeronautics and Space Administration; the development and evaluation of color display systems for military applications for the Naval Air Test Center; and the objective determination of local muscle fatigue via electrophysiological and performance measures for the American Postal Workers Union.

May 1980 to June 1983

Research Scientist - The Boeing Company, Seattle, Washington

Research and analysis in human performance applied to advanced technology aerospace systems. Major responsibilities for the development, analysis, and interpretation of experimental tests and evaluations. Emphasis on perceptual-motor and cognitive factors in human interface design.

Specific projects involved computer-based displays and control systems, information requirements and coding, visual performance, and operator workload measurement.

2. *August 1979 to May 1980*

Human Factors Specialist - Rockwell International Corporation, Cedar Rapids, Iowa

Participation in development of high-contrast, multi-color CRT displays for aircraft instrument applications. Research and application in the areas of color vision, visual information processing, display symbology and format design, visual fatigue and operator workload, and pilot acceptance and training requirements.

Additional work on intelligibility requirements of computer-processed voice messages for aircraft advisory and warning signals.

June 1977 to August 1979

National Institute of Health Postdoctoral Research Fellow - Psychophysiology Research Unit - University of Wisconsin, Madison.

Career development award supporting advanced research and training in theory and laboratory techniques in Psychophysiology, Psychophysics, Sensory Neuroscience, and Electromyography.

Research on reflex modulation as a function of parameters of sensory input, states of consciousness, under varying conditions of selective attention and cognitive

workload, and as a developmental factor. Additional work on the differentiation of transient and sustained sensory and motor systems and their relative participation in different aspects of human performance.

Developed micro-miniature, artifact-free biopotential recording electrodes and participated in the development of a system for monitoring eyeblinks and eye movements using pulse-coded infra-red reflectance and fiber optic techniques.

September 1972 to June 1977

Graduate Research and Teaching Assistant - University of Florida

Conducted extensive research oriented toward investigation of relationships between human perceptual and memory processes and psychophysiological measures of information processing. Combined minor in Computer Science and Biomedical Electronics completed.

Assumed primary responsibilities for setup and maintenance of a computer-based laboratory involved in sensory/perceptual, cognitive, information processing, and psychophysiological research.

Supervised one phase of research for NIH-NINDS contract to develop batteries of tests for visual and auditory sensitivity and sensory discrimination in infants and young children.

Conducted human EEG research on frequency-specific brainwave patterns and biological rhythms.

September 1972 to July 1975

Graduate Teaching Assistant and Independent Research - University of Florida.

Assisted in teaching courses on Psychophysics, Perception, and Human Information Processing.

Supervised a research project on the development of psychophysical methods for animal subjects and participated in research involving the development of a visual prosthesis via brain stimulation techniques.

PUBLISHED AND PRESENTED PAPERS

Silverstein, L. D. Fundamentals of Vision and Color Science for Display Technologists. An invited short-course presented to the International Conference of The Society for Information Display, presented annually from May 2005 – May 2007. (Published manuscript in SID Short Course Lecture Notes, 2006, Short Course S-4, S-4/1-S-4/85).

Silverstein, L. D. Color display technology: From pixels to perception. *Proceedings of the Thirteenth Color Imaging Conference*, 2005, 136-140.

Silverstein, L. D. Color and displays in the space-time continuum. *Information Display*, 2005, *21*, 21-27.

Silverstein, L. D. STColor: Hybrid spatial-temporal color synthesis for enhanced display image quality. *Society for Information Display Technical Digest*, 2005, 1112-1115.

Silverstein, L. D. Display visibility in dynamic lighting environments: Impact on the design of portable and vehicular displays. *Proceedings of the International Display Manufacturing Conference* (Taipei, Taiwan), 2003, 15-18.

Silverstein, L. D. Color matrix displays: A paradigm shift for the future of electronic color imaging. In L. MacDonald and A. Lowe (Eds.), *Display Systems: Design and Applications*, New York: John Wiley & Sons, Inc., 1997.

Silverstein, L. D. Review of "Foundations of Vision." *Color Research and Application*, 1996, *21*, 142-144.

Silverstein, L. D. Color in Electronic Displays. An invited seminar presented to the International Conference of The Society for Information Display, presented annually from May 1995 – May 2004. (Published manuscript in *SID Seminar Lecture Notes*, 2004, Volume 1, M13/1-M13/63).

Silverstein, L. D. Color matrix displays: A paradigm shift for the future of electronic color imaging. Proceedings of the conference on "Getting the Best from State-of-the-Art Display Systems," The National Gallery of London, United Kingdom, February, 1995.

Silverstein, L. D. Color in CRT and LC Displays. An invited seminar presented to the International Conference of The Society for Information Display, San Jose, California, June 1994. (Published manuscript in *SID Seminar Lecture Notes*, 1994, Volume 2, F3/3-F3/70).

Silverstein, L. D. Smart Color Displays. An Invited Seminar Presented at *Smart Color '94*. Stanford University, Stanford, California, October 1994.

Silverstein, L. D. Smart Color Displays. An Invited Seminar Presented at *Smart Color '93*. Stanford University, Stanford, California, October 1993.

Silverstein, L. D. Review of "Effective Color Displays: Theory and Practice." *Color Research and Application*, 1992, *17*, 147-148.

Silverstein, L. D. Review of "Using Computer Color Effectively: An Illustrated Reference." *Color Research and Application*, 1990, *6*, 361-363.

Silverstein, L. D. An Applied Perspective on Color Difference Measurement. An Invited Paper Presented to the 1988 Annual Meeting of the Optical Society of America, Santa Clara, California, October 1988.

Silverstein, L. D. Human factors for color display systems: Concepts, methods, and research. In J. Durrett (Ed.), *Color And The Computer*. New York: Academic Press, Inc., 1987.

Silverstein, L. D. Color Displays: A product of vision or a problem of perception. An invited presentation to the Air Line Pilots Association Symposium on Human Performance. Washington, D.C., December 1983.

Silverstein, L. D. Human factors for color information displays. An invited seminar presented to the International Conference of The Society for Information Display, San Diego, California, May 1982. (Published manuscript in *SID Seminar Lecture Notes*, 1982, Volume 2, 1-41).

Silverstein, L. D. & Berg, W. K. Psychophysiological correlates of human sensory and memory processes. American Psychological Association: *JSAS Series of Selected Documents in Psychology*, 1977, MS#1587.

Silverstein, L. D. & Berg, W. K. Repetition and distribution effects on memory: A psychophysiological analysis. *Psychophysiology*, 1978, *15*, 293-294.

Silverstein, L. D., and Fiske, T. G. Colorimetric and photometric modeling of liquid crystal displays. *Proceedings of the First IS&T/SID Color Imaging Conference: Transforms and Transportability of Color*, 1993, 149-156.

Silverstein, L. D., Gomer, F. E., Crabtree, M. S., & Acton, W. H. A comparison of analytic and subjective techniques for estimating communications related workload during transport flight operations. National Aeronautics and Space Administration, Technical Report #NAS2-11562, Ames Research Center, California, January 1984.

Silverstein, L. D., Gomer, F. E., Yeh, Y., & Krantz, J. H. Empirical studies of color matrix display image quality. *Applied Vision: Optical Society of America Technical Digest Series*, 1989, *16*, 152-157.

Silverstein, L. D. & Graham, F. K. Eyeblink EMG: A Micro-miniature electrode for recording from orbicularis oculi. *Psychophysiology*, 1978, *15*, 377-380.

Silverstein, L. D. & Graham, F. K. Selective attention effects on reflex activity. *Psychophysiology*, 1979, *16*, 202.

Silverstein, L. D. & Graham, F. K. Orbicularis oculi excitability and prestimulation effects during NREM and REM sleep. *Psychophysiology*, 1979, *16*, 207.

Silverstein, L. D., Graham, F. K., & Bohlin, G. Selective attention effects on the reflex blink. *Psychophysiology*, 1981, *18*, 240-248.

Silverstein, L. D., Graham, F. K., & Calloway, J. M. Preconditioning and excitability of the human orbicularis oculi reflex as a function of state. *Electroencephalography and Clinical Neurophysiology*, 1980, *48*, 406-417.

Silverstein, L. D., Krantz, J. H., Gomer, F. E., Yeh, Y., & Monty, R. W. The effects of spatial sampling and luminance quantization on the image quality of color matrix displays. *Journal of the Optical Society of America A*, 1990, *7*, 1955-1968.

Silverstein, L. D., Lepkowski, J. C., Carter, R. C., & Carter, E. Display color modeling and algorithmic color selection. *Proceedings of the SPIE: Advances in Display Technology VI*, 1986, 26-35.

Silverstein, L. D., and Lepkowski, J. S. The perception of primary area spatial distribution in color information displays. *Society for Information Display Technical Digest*, 1986, 416-419.

Silverstein, L. D. & Levy, C. M. The stability of the sigma spindle. *Electroencephalography and Clinical Neurophysiology*, 1976, *40*, 666-671.

Silverstein, L. D. & Merrifield, R. M. *The Development and Evaluation of Color Display Systems for Airborne Applications: Phase I - Fundamental Visual, Perceptual, and Display System Considerations*. Technical Report DOT/FAA/PM-85-19, July 1985. (Also published as Technical Report NADC-86011-60, February 1986.)

Silverstein, L. D. & Merrifield, R. M. Color selection and verification testing for airborne color CRT displays. *Proceedings of the Fifth Advanced Aircrew Display Symposium*. Naval Air Test Center, Patuxent River, Maryland, September 1981, 39-81.

Silverstein, L. D., Merrifield, R. M., Smith, W. D. & Hoerner, F. A systematic program for the development and evaluation of airborne color display systems. *Proceedings of the Sixth Advanced Aircrew Display Symposium*, Naval Air Test Center, Patuxent River, Maryland, May 1984, 3-44.

Silverstein, L. D., Monty, R. W., Gomer, F. E. and Yeh, Y. Y. A Psychophysical Evaluation of Pixel Mosaics and Gray-Scale Requirements for Color Matrix Displays. *Society for Information Display Digest of Technical Papers*, 1989, 128-131.

Silverstein, L. D., Monty, R. W., Huff, J. W. and Frost, K. Image quality and visual simulation of color matrix displays. *Proceedings of the Society of Automotive Engineers (SAE) Aerotech 1987 - Human Behavioral Technology*, Paper No. 871789.

Silverstein, L. D., and Paukshto, M. V. Thin crystal films (TCF) for LCD color correction. *Society for Information Display Technical Digest*, 2003, 824-827.

Silverstein, L. D., Roosendaal, S. J., and Jak, M. J. J. Hybrid spatial-temporal color synthesis and its applications. *Journal of the Society for Information Display*, 2006, 14, 3-13.

Berg, W. K., Silverstein, L. D., Krantz, J. H., McGovern, J. B., and Donohue, R. L., The development of an objective, electromyographic measure of VDT induced visual stress. *Society for Information Display Technical Digest*, 1988, 348-351.

Berg, W. K., Silverstein, L. D., Tweed, N. V., & Clarkson, M. Enhanced cardiac deceleration to near-threshold acoustic stimuli in infants. *Psychophysiology*, 1977, *14*, 98-100.

Berg, W. K., Clarkson, M., & Silverstein, L. D. Inhibition of infants' reflex blinks by near-threshold auditory stimuli. *Psychophysiology*, 1979, *16*, 191. (Abstract of presented paper.)

Berg, W. K., Clarkson, M., Silverstein, L. D., & Tweed, N. V. Cardiac responses in infants to low-intensity auditory stimuli. Paper presented at the 23rd meeting of the Southeastern Psychological Association, Hollywood, Florida, 1977.

Berg, W. K., Donohue, R. L., Haerick, P., and Silverstein, L. D. Examining the Entire Spectrum of Results: Electromyographic Information Lost to the Contour-Following Integrator. *Psychophysiology*, 1988, *25*, 434-435.

Bohlin, G., Graham, F. K., Silverstein, L. D., & Hackley, S. A. Cardiac orienting and startle blink modification in novel and signal situations. *Psychophysiology*, 1981, *18*, 603-611.

Brill, M. H., and Silverstein, L. D. Iso-luminous color difference metric for application to displays. *Society for Information Display Technical Digest*, 2002, 33, 809-811.

Cobb, C., Gerbaz, C., Lazarev, P., Paukshto, M., & Silverstein, L. LCD with 7-micron light management path. *Proceedings of the Photonics West Conference and Exhibition*, 2002.

Colegrove, J., Kelly, J., Fiske, T., Lewis, A., Yuan, H., Tran, H., Crawford, G. P., & Silverstein, L. D. Technology of stacking HPDLC for higher reflectance. *Society for Information Display Technical Digest*, 2000, 31, 770-773.

Colegrove, J., Fiske, T., Lewis, A., Yuan, H., Bowley, C., Crawford, G. P., Kelly, J., & Silverstein, L. D. The effect of monomer funtionality on HPDLC performance and aging. *Society for Information Display Technical Digest*, 2001, 32, 962-965.

Crawford, G. P., Silverstein, L. D., & Fiske, T. G. Reflective color displays for imaging applications. *Proceedings of the IS&T/SID 1995 Color Imaging Conference*, 1995, 52-58.

Crawford, G. P., Fiske, T. G., & Silverstein, L. D. Reflective color LCDs based on H-PDLC and PSCT technologies. *Society for Information Display Technical Digest*, 1996, 99-102.

Crawford, G. P., Silverstein, L. D., & Fiske, T. G. Reflective color LCDs based on H-PDLC and PSCT technologies. *Journal of the Society for Information Display*, 1997, *5*, 1, 45-48.

Danner, G. M., Fiske, T. G., & Silverstein, L. D. (2001). Display performance for mobile device applications. *Proceedings of Asia Display: The 21st International Display Research Conference*, 1653-1656.

Escuti, M. J., Kossyrev, P., Bowley, C. C., Danworaphong, S., Crawford, G. P., Fiske, T. G., Colvegrove, J., Silverstein, L. D., Lewis, A., & Yuan, H. Diffuse H-PDLC reflective displays: An enhanced viewing angle approach. *Society for Information Display Technical Digest*, 2000, 31, 766-773.

Escuti, M. J., Kossyrev, P., Crawford, G. P., Fiske, T. G., Colvegrove, J., & Silverstein, L. D. Expanded viewing-angle reflection from diffuse holographic-polymer dispersed liquid crystal films. *Applied Physics Letters*, 2000, 77, 4262-4264.

Fiske, T. G., Silverstein, L. D., Hodgson, S., & Watson, A. B. Visual quality of high-contrast projection screens. Part I: Visibility of screen-based artifacts and noise. *Journal of the Society for Information Display*, 2007, 15, 409-419.

Fiske, T. G., & Silverstein, L. D. Display modulation by Fourier transform. *Information Display*, 2007, 23, 24-27.

Fiske, T. G., & Silverstein, L. D. Display modulation by Fourier transform: A preferred method. *Journal of the Society for Information Display*, 2006, 14, 101-105.

Fiske, T. G., & Silverstein, L. D. Estimating display modulation by 2-D Fourier transform: A preferred method. *Society for Information Display Technical Digest*, 2005, 1326-1329.

Fiske, T. G., Silverstein, L. D., Colegrove, J., & Yuan, H. H-PDLC color separation device for image capture systems. *Society for Information Display Technical Digest*, 2000, 31, 1134-1137.

Fiske, T. G., Silverstein, L. D., Penn, C., & Kelly, E. F. Viewing angle: A matter of perspective. *Society for Information Display Technical Digest*, 1998, 937-940.

Fiske, T. G., & Silverstein, L. D. Modeling and optimization of color gamut and color tracking in high-performance AMLCDs. *Society for Information Display Technical Digest*, 1994, 329-332.

Fiske, T. G., & Silverstein, L. D. Accurate color rendering for display simulation. *Society for Information Display Technical Digest*, 1993, 133-136.

Fiske, T. G., & Silverstein, L. D. Characterization of viewing-angle dependent colorimetric and photometric performance of color LCDs. *Society for Information Display Technical Digest*, 1993, 565-568.

Gomer, F. E., Silverstein, L. D., Berg, W. K., & Lassiter, D. L. Changes in electromyographic activity associated with occupational stress and poor performance in the workplace. *Human Factors*, 1987, *29*, 131-143.

Gomer, F. E., Silverstein, L. D., Monty, R. W., Huff, J. W., and Johnson, M. J. A perceptual basis for comparing pixel selection algorithms for binary color matrix displays. *Society for Information Display Technical Digest*, 1988, 435-438.

Hall, D. C., Silverstein, L. D., & Willis, R. D. Concurrent variable interval schedules with food and water reinforcers. *Psychological Record*, 1976, *26*, 423-433.

Jachimowicz, K. E., Kelly, G. R., & Silverstein, L. D. Display human factors research and resources at the PTC. *Motorola Annual Display Technology Symposium Digest of Technical Papers*, 1996, 67-74.

Krantz, J. H., & Silverstein, L. D. Visibility of active matrix LCDs under simulated cockpit lighting conditions. *Society for Information Display Technical Digest*, 1991, 806-810.

Krantz, J. H., & Silverstein, L. D. Color matrix display image quality: The effects of luminance and spatial luminance sampling. *Society for Information Display Technical Digest*, 1990, 29-32.

Krantz, J. H., & Silverstein, L. D. The Gray-Scale Asymptote for Anti-aliasing Graphic Images on Color Matrix Displays. *Society for Information Display Technical Digest*, 1989, 139-142.

Krantz, J. H., Silverstein, L. D., and Yeh, Y. Y. Visibility of transmissive liquid crystal displays under dynamic lighting conditions. *Human Factors*, 1992, *34*, 615-632.

Larimer, J., Silverstein, L. D., Samadani, R., Lanham, J., Loomis, D., Marks, B., Gille, J., Martin, R., Lubin, J., Pica, A., Berreman, D., & den Boer, W. A video engineering and optimization system (ViDOES). *Society for Information Display Digest of Technical Papers*, 1994, 197-200.

Lazarev, P., Paukshto, M. V., Fiske, T. G., and Silverstein, L. D. Thin crystal films (TCF) for LCD contrast enhancement. *Society for Information Display Technical Digest*, 2003, 669-671.

Lee, D. D., Da Costa, V., Lewis, A. G., Martin, R. A., Silverstein, L. D., and Bruce, R. A universal controller architecture for active matrix liquid crystal displays. *Society for Information Display Technical Digest*, 1992, 605-608.

Levy, C. M., and Silverstein, L. D. Sleep stage and organismic characteristics of the sigma sleep spindle. *Sleep Research*, 1975, *4*, 259-260.

Martin, R. A., Batey, J., Nguyen, M., Raber, E., Siemens, D., Steemers, H., Stuber, S., Thompson, M., Turner, W., Tilton, M., Silverstein, L. D., and Potts, M. Design of high-resolution AMLCDs with greater that 2000 gate lines. *Society for Information Display Technical Digest*, 1997, 7-10.

Martin, R. A., Chuang, H., Steemers, R., Fulks, R., Stuber, D., Lee, D., Young, M., Ho, J., Nguyen, M., Meuli, W., Fiske, T., Bruce, R., Da Costa, V., Kowalski, R. P., Lewis, A., Turner, W., Thompson, M. J., Tilton, M., and Silverstein, L. D. The electronic document display: A 6.3 million-pixel AMLCD. *Journal of the Society for Information Display*, 1996, 4, 65-73.

Martin, R. A., Chuang, H., Steemers, H., Allen, R., Fulks, R., Stuber, D., Lee, D., Young, M., Ho, J., Nguyen, M., Meuli, W., Fiske, T., Bruce, R., Thompson, M., Tilton, M., and Silverstein, L. D. A 6.3 million pixel AMLCD. *Society for Information Display Technical Digest*, 1993, 704-707.

Martin, R. A., Middo, K., Turner, W., Lewis, A., Thompson, M., and Silverstein, L. D. A high-resolution AMLCD for the electronic library system. *Proceedings of the SPIE Conference on Cockpit Displays*, 1994, *2219*, 89-96..

Merrifield, R. M., and Silverstein, L. D. Color analysis for airborne CRT displays. *Society for Information Display Technical Digest*, 1982, 196-197.

Merrifield, R. M. and Silverstein, L. D. An automatic brightness and contrast control system for vehicular displays. *Society for Information Display Technical Digest*, 1988, 178-181.

Monty, R. W., Silverstein, L. D., Frost, K., and Boyle, L. A color matrix display image simulation system for human factors research. *Society for Information Display Technical Digest*, 1987, 119-122.

Paukshto, M., Pan, Y-H., & Silverstein, L. D. Compensated TN LCD with color perfection film (CPF). *Society for Information Display Technical Digest*, 2005, 1475-1477.

Paukshto, M., and Silverstein, L. D. Two novel applications of thin-film E-type polarizers. *Society for Information Display Technical Digest*, 2002, 33, 722-725.

Paukshto, M., and Silverstein, L. D. Viewing angle enhancement of TN LCD using E-type polarizers. *Society for Information Display Technical Digest*, 2001, 32, 902-905.

Penn, C., & Silverstein, L. D. FED design factors for optimum viewability in automotive applications. *Proceedings of the SID Annual Flat-Panel Display Strategic and Technical Symposium*, 1998, 33-37.

Samadani, R., Lanham, J., Loomis, D., Silverstein, L. D., & Larimer J. Periodic plane tilings: Application to pixel layout simulations for color flat-panel displays. *Journal of the Society for Information Display*, 1994, 95-104.

Samadani, R., Lanham, J., Loomis, D., Silverstein, L. D., & Larimer, J. Color tilings for flat-panel displays. *Society for Information Display Technical Digest*, 1993, 83-86.

Strock, B. D., Graham, F. K., & Silverstein, L. D. Infant reflex excitability during active and quiet sleep. *Psychophysiology*, 1981, *18*, 174. (Abstract of presented paper.)

Trimmier, J. R., Gold, R. S., Jachimowicz, K. E., & Silverstein, L. D. Full-color subtractive light valve for display applications. *Proceedings of the SPIE/SPSE: Display Devices and Controllers for Electronic Imaging*, in press.

Wandell, B. A., & Silverstein, L. D. Digital color reproduction. In S. Shevell (Ed.), *The Science of Color, 2nd Edition*. Washington, D. C.: Optical Society of America, 2003, 281-316.

Yeh, Y., & Silverstein, L. D. Spatial judgments with monoscopic and stereoscopic presentation of perspective displays. *Human Factors*, 1992, *34*, 583-600.

Yeh, Y., & Silverstein, L. D. Human factors issues in stereoscopic visual displays. *Society for Information Display Technical Digest*, 1991, 826-829.

Yeh, Y., & Silverstein, L. D. Limits of fusion and depth judgment in stereoscopic color displays. *Human Factors*, 1990, *32*, 45-60.

Yeh, Y., & Silverstein, L. D. Visual performance with monoscopic and stereoscopic presentations of identical three-dimensional visual tasks. *Society for Information Display Digest of Technical Papers*, 1990, 359-362.

Yeh, Y., & Silverstein, L. D. Using Electronic Stereoscopic Displays: Limits of Fusion and Depth Discrimination. *Proceedings of the SPIE: Three-Dimensional Visualization and Display Technologies*, 1989, *1083*, 197-204.

Yeh, Y., and Silverstein, L. D. Depth Discrimination in Stereoscopic Displays. *Society for Information Display Digest of Technical Papers*, 1989, 372-376.

Yu, S., Jachimowicz, K. E., & Silverstein, L. D. A Photometric and colorimetric model of field emission displays. *Motorola Annual Display Technology Symposium Digest of Technical Papers*, 1996, 35-42.

Yu, S., Penn, C. W., Jachimowicz, K. E., & Silverstein, L. D. How fill factor affects display image quality. *Society for Information Display Technical Digest*, 1998, 1116-1119.

Yuan, H., Fiske, T., Lewis, A., & Silverstein, L. D. Wide-viewing-angle TFT-LCDs optimized for desktop and avionics applications. *Society for Information Display Technical Digest*, 1998, 714-717.

Yuan, H., Hu, G., Fiske, T., Lewis, A., Gunther, J. E., Silverstein, L. D., Bowley, C., Crawford, G. P., Chien, L. C., & Kelly, J. R. High efficiency color reflective displays with extended viewing angle. *Proceedings of Asia Display: The 18th International Display Research Conference*, 1998, 1136-1139.

Yuan, H., Colegrove, J., Hu, G., Fiske, T., Lewis, A., Gunther, J., Silverstein, L., Bowley, C., Crawford, G., Chien, L., and Kelly, J. HPDLC color reflective displays. *SPIE Conference on Avionics Displays*, Vol. *3690*, 1999, xx-xx.

CORPORATE TECHNICAL DOCUMENTS

Silverstein, L. D. The Use of Optiva Thin Crystal Film (TCF) Materials for LCD Color Correction. Technical Report for Optiva, Inc. February, 2002.

Silverstein, L. D. A 240 Degree Super-Twisted Nematic LCD Design Employing the Optical Mode Interference Effect. Technical Report for Optiva, Inc. August, 2001.

Silverstein, L. D. Psychophysical and Perceptual Issues in the Development of Perceptually Continuous Tiled Displays. Technical Report for the Philips Flat Display Systems Group. May, 2000.

Silverstein, L. D. *The Truth About Field-Sequential Color Displays*. Technical Report and Dynamic Visual Test Patterns for Colorado MicroDisplay, Inc. October, 1999.

Silverstein, L. D. *The Perception of Flicker in Microdisplay Virtual Viewers*. Technical Report for Colorado MicroDisplay, Inc. July, 1999.

Silverstein, L. D. *Temporal and Spatial Visual Factors in Laser Projection Displays*. Hughes Aircraft Company, Ground Systems Group. Final Contract Report, July, 1991.

Silverstein, L. D. *Display Color Modeling and Algorithmic Color Selection: Technical Background and Software User's Manual*. Honeywell Inc., Systems and Research Center, Technical Report H74-5410-00-00, October 1987.

Silverstein, L. D. *Human Factors Considerations In The Development of Shadow-mask Color CRT Displays*. Rockwell International Corporation, Collins Divisions, Internal Technical Report, March 1980.

Silverstein, L. D., Gomer, F. E., Monty, R. W., and Yeh, Y. *An Optimal Pixel Arrangement for Graphic Images Presented on Binary Color Matrix Displays*. Honeywell Inc., Systems and Research Center Technical Report R74-2891-01-00, January 1988.

Silverstein, L. D., Turner, B. L., & Bernstein, A. D. *Electronic Flight Instrument System: Human Engineering Analysis for Flight Mode Annunciation*. Boeing Commercial Airplane Company, Technical Report SYST-B8765-40-C80-36, July 1980.

Silverstein, L. D., & Turner, B. L. *Electronic Flight Instrument System: Optimum Visibility Parameters for Decision Height Indication*. Boeing Commercial Airplane Company, Technical Report SYST-B8765-40-C81-096, February 1981.

Silverstein, L. D., & Turner, B. L. *A Multivariate Analysis of Pilot Tracking Performance with Alternative Flight Director Symbologies*. Boeing Commercial Airplane Company, Technical Report SYST-B8765-40-C82-117, June 1981.

Silverstein, L. D., & Merrifield, R. M. *Minimum Linewidth and Defocus Parameters for Shadow-Mask Color CRT Displays*. Boeing Commercial Airplane Company, Technical Report SYST-B8765-40-C81-148, October 1981.

Silverstein, L. D., & Merrifield, R. M. *Minimum Brightness Levels for EFIS Color Displays*. Boeing Commercial Airplane Company, Technical Report SYST-B8765-20-C82-018, September 1982.

Silverstein, L. D., Yeh, Y. Y., Hancock, W. R., Huff, J., Gomer, F. E., Johnson, M. J., & Larson, H. *Advanced TCAS III Research and Development Project (ATSD/FAA): TCAS III Display Analysis*. Honeywell Inc., Systems and Research Center, Technical Report in press. (Final Report for Federal Aviation Administration Contract No. DFTA01-85-C-0005), April 1990.

Gomer, F. E., Krantz, J. H., Silverstein, L. D., & Huff, J. W. *Evaluating Liquid Crystal Displays Used to Present Sensor Video and Digital Color Map Images: Effects of Pixel Density and Number of Gray Levels on Image Quality*. Honeywell Inc., Systems and Research Center, Technical Report R76-2891-01-00 (U. S. Army LHX Contract No. RCP003A), September 1989.

Gomer, F. E., Silverstein, L. D., Monty, R. W., Huff, J. W. and Johnson, M. J. *Optimal Pixel Selection Algorithms for Binary Color Matrix Displays*. Honeywell Inc., Systems and Research Center, Technical Report H74-5410-01-00, November 1987.

Jachimowicz, J., Silverstein, L. D., & Richard, F. *The Human Factors of Virtual Display Pagers*. Motorola Phoenix Corporate Research Laboratories, Technical Report PCRL-93-3, 1993.

Jachimowicz, J., Kelly, G., Silverstein, L. D., & de la Torre, D. *Thunderbolt Visual Resolution Human Factors Study*. Motorola Phoenix Corporate Research Laboratories, Technical Report PCRL-94-1, 1994.

Kelly, B. D. & Silverstein, L. D. *Boeing 757/767 Crew Alerting System Verification Tests*. Boeing Commercial Airplane Company, Technical Document D230T408, January 1983.

Sims, F. A., Silverstein, L. D. & McElroy, J. J. *Electronic Flight Instrument System: An Evaluation of Pilot Tracking Performance with Alternative Navigation Display Formats*. Boeing Commercial Airplane Company, Technical Document D230T407-510TN, May 1982.

Patents

1) "Four Color Repetitive Sequence Matrix Array for Flat Panel Displays" by Louis D. Silverstein and Robert W. Monty, U.S. Patent Number 4,800,375 - assigned to Honeywell, Inc.

2) "Apparatus and Method for an Electronically Contolled Color Filter for Use in Information Display Applications" by Louis D. Silverstein and Anthony J. Bernot, U.S. Patent Number 5,032,007 - assigned to Honeywell, Inc.

3) "Full Color Three-Dimensional Display System" by Ronald S. Gold, Karen E. Jachimowicz, William Hancock, and Louis D. Silverstein, U.S. Patent Number 5,074,645 - assigned to Honeywell, Inc.

4) "Two Path Liquid Crystal Light Valve Color Display With Light Coupling Lens Array Disposed Along The Red-Green Light Path" by Robert A. Sprague, Louis D. Silverstein and Richard H. Bruce. U.S. Patent Number 5,315,418 - assigned to Xerox Corporation.

5) "Two Path Liquid Crystal Light Valve Color Display" by Louis D. Silverstein and Richard H. Bruce, U.S. Patent Number 5,642,125 - assigned to Xerox Corporation.

6) "Large Screen Full Color Display With Plural Adjacent Display panels and Enlarging Gradient Index Lens Array" by Robert A. Sprague, Louis D. Silverstein, and Richard H. Bruce. U.S. Patent Number 5,504,598 - assigned to Xerox Corporation.

7) Full Color Display With Gradient Index Lens Array@ by Robert A. Sprague, Louis D. Silverstein, and Richard H. Bruce. U.S. Patent Number 5,504,597 - assigned to Xerox Corporation.

8) "Full Color Display With Plural Two-Dimensional Planar Array of Lenslets" by Robert A. Sprague, Louis D. Silverstein, and Richard H. Bruce. U.S. Patent Number 5,550,656 - assigned to Xerox Corporation.

9) "Enhanced Off-Axis Viewing Performance and Luminous Efficiency of a Liquid Crystal Display Employing Fiber-Optic Faceplate Elements" by Louis D. Silverstein, Thomas G. Fiske, Richard H. Bruce, and Robert A. Sprague, U.S. Patent Number 5,442,467 - assigned to Xerox Corporation.

10) "Enhanced Off-Axis Viewing Performance of a Liquid Crystal Display Employing a Fiber-Optic Faceplate Having An Opaquely Masked Front Surface on the Front Face" by Louis D. Silverstein, and Thomas G. Fiske, U.S. Patent Number 5,959,711 - assigned to Xerox Corporation.

11) "Universal Display That Presents All Image Types with High Image Fidelity" by Russell A. Martin, Richard H. Bruce, Victor M. DaCosta, Thomas G. Fiske, Alan G. Lewis, Louis D. Silverstein, Hugo L. Steemers, Malcolm J. Thompson, and William D. Turner, U.S. Patent Number 5,703,621 - assigned to Xerox Corporation.

12) "Thin-Film Structure with Dense Array of Binary Control units for Presenting Images" by Robert R. Allen, Richard H. Bruce, Tzu-Chin Chuang, Thomas G. Fiske, Ronald T. Fulks, Michael Hack, Jackson H. Ho, Alan G. Lewis, Russell A. Martin, Louis D. Silverstein, Hugo L. Steemers, Susan M. Stuber, Malcolm J. Thompson, William D. Turner, and William W. Yao, U.S. Patent Number 5,491,347 - assigned to Xerox Corporation.

13) “Image Generator For Use in Image Manifestation Apparatus” by Karen Jachimowicz, Louis D. Silverstein, George Kelly, and Fred Richard, U.S. Patent Number 5,630,001 - Assigned to Motorola Inc.

14) “Optical Equivalents of Fiber Optic Face Plates using Reactive Liquid Crystals and Polymers” by Gregory P. Crawford, Louis D. Silverstein and Thomas G. Fiske, U.S. Patent Number 5,726,730, assigned to Xerox Corporation.

15) “Enhanced Off-Axis Viewing Performance of Liquid Crystal Display Employing a Fiber-Optic Faceplate in Conjunction with Dual Negative Retarders and a Brightness Enhancing Film on the Illumination Source” by Gregory P. Crawford, Louis D. Silverstein, and Thomas G. Fiske, U.S. Patent Number 5,751,390, assigned to Xerox Corporation.

16) “Liquid Crystal Cell Constructed to Produce a Highly Anisotropic Light Distribution Possessing Extremely High Contrast Around a Narrow Meridian” by Gregory P. Crawford, Thomas G. Fiske, and Louis D. Silverstein U.S. Patent Number 5,867,240, assigned to Xerox Corporation.

17) “Broadband Reflective Display and Methods of Forming Same” by Louis D. Silverstein, Gregory P. Crawford and Thomas G. Fiske, and U.S. Patent Number 5,875,012, assigned to Xerox Corporation.

18) “Methods to Fabricate Optical Equivalents of Fiber Optic Face Plates using Reactive Liquid Crystals and Polymers” by Gregory P. Crawford, Louis D. Silverstein and Thomas G. Fiske, U.S. Patent Number 5,928,819, assigned to Xerox Corporation.

19) “LCDs with Wide Viewing Angle” by Haiji Yuan, Thomas G. Fiske, Louis D. Silverstein and Jack R. Kelly, U.S. Patent Number 6034756, assigned to Xerox Corporation.

20) “Paper-White Reflective Display and Methods of Forming Same” by Gregory P. Crawford, Thomas G. Fiske and Louis D. Silverstein, U.S. Patent Number 6,130,732 assigned to Xerox Corporation.

21) “Holographically Formed Reflective Display, Liquid Crystal Display and Projection System and Methods of Forming the Same” by Louis D. Silverstein, Thomas G. Fiske and Gregory P. Crawford, U.S. Patent Number 6,133,971 assigned to Xerox Corporation.

22) “Solid-State Image Capture System Including H-PDLC Color Separation Element” by Louis D. Silverstein, Thomas G. Fiske and Haiji Yuan, U.S. Patent Number 6,166,800 assigned to Xerox Corporation.

23) “High-efficiency Reflective Liquid Crystal Display” by Haiji Yuan, Thomas G. Fiske and Louis D. Silverstein, U.S. Patent Number 6,317,189 assigned to Xerox Corporation.

24) “Enhanced Viewing Angle Performance on Non-Polarizer Based Color Reflective Liquid Crystal Display Using a Fiber-Optic Faceplate” by Louis D. Silverstein, Thomas G. Fiske and Gregory P. Crawford, U.S. Patent Number 6,339,463 assigned to Xerox Corporation.

25) “Liquid Crystal Display With Touch Panel Having Internal Front Polarizer” by Michael V. Paukshto and Louis D. Silverstein, U.S. Patent Number 7,190,416 assigned to Nitto Denko Corporation.

26) “Color Correcting Polarizer” by Michael V. Paukshto and Louis D. Silverstein, U.S. Patent Number 7,144,608 assigned to Nitto Denko Corporation.

27) “Color Liquid Crystal Display with Internal Rear Polarizer” by Michael V. Paukshto and Louis D. Silverstein, U.S. Patent Number 7,271,863 assigned to Nitto Denko Corporation.

28) “Non-Absorbing Polarization Color Filter and Liquid Crystal Display Incorporating the Same” by Pavel I. Lazarev, Michael V. Paukshto, Louis D. Silverstein and Pochi Yeh. U.S. Patent Number 7,324,181 assigned to Nitto Denko Corporation.

****Seven additional patents currently pending, including those with Nitto Denko Corporation, Inc., Aurora Systems, Inc., Qualcomm, Inc., Freescale Semiconductor, Inc., and Dolby Laboratories, Inc.**

Exhibit B

Plaintiff's Proposed Claim Construction

U.S. Patent No. 7,113,152

Claim and Claim Element	Genoa's Proposed Construction	Support for Genoa's Proposed Construction
1. A method of producing a **color image** comprising:	an image including a plurality of pixels, at least some of which are made up of at least four non-white and non-black colors.	The preamble constitutes a limitation of claim 1, because its reference to "color image" provides an antecedent basis for the term, "said color image" that occurs in the body of the claim as discussed below. Claim 1 on its face states that "said color image" is produced by spatially modulating light of at least four colors (see below). One of ordinary skill would understand the term, "color image" as shown on an "electronic true color display" (1:2) to require and consist of a plurality of pixels, each of which corresponds to a portion of the image. (9:11) As stated in the Abstract, the invention is for "a device, system and a method for displaying image data of a plurality of colors, the device comprising a light source for producing light of having at least four primary colors," and "is not limited to combinations of colors which are produced from only three primary colors, such as red, green and blue." The "Summary of the Invention" discloses "a device for displaying image data of a plurality of colors, the device comprising a light source for producing light having at least four primary colors and a viewing screen for displaying the image," including "projecting the light of each primary color according to the path onto the viewing screen to form the image." (4:44-55) The invention is for "displaying an expanded gamut of colors, namely four or more primary colors." In this context, one of ordinary skill would understand that black does not constitute a primary color. The "color image" is an image projected onto a viewing screen (9:13-15) that consists of a "full color image" with "a wide gamut of colors." (10:2,

		19-20) At the time of the invention, one of ordinary skill would have understood that the term "color image" means an image including a plurality of pixels, made up of at least four non-white and non-black colors.
projecting **polychromatic light** from a light source onto a first side of a color wheel having at least four non-white and non-black color filters;	light including a plurality of wavelengths	One of ordinary skill would understand that the term "polychromatic light" refers to light including a plurality of wavelengths. The specification refers to "white or polychromatic" light. (4:16) It discloses further that when white light is passed through a filter, it forms colored light of a defined spectral range. (8:65-67)
rotating said color wheel such that the polychromatic light from said light source is sequentially filtered by transmission through said at least four color filters to sequentially produce at a second side of said color wheel, opposite said first side, light of at least four colors, each of said at least four colors having a different chromaticity from the others of the at least four colors; and	no construction needed	The terms included in this element all possess their ordinary meanings.

spatially modulating	varying the intensity and/or color and/or angular distribution and/or polarization of light as a function of spatial position	"The light beam is spatially modulated by spatially modulated mask 56, so that the apparent brightness of each primary color varies a different portion of the viewing screen 60…" (10:7-10) As shown on Figures 3A and 3B, light of at least four colors shines sequentially on spatial modulator 56 that possesses individual pixels 70. In the case of a DMD or digital micro-mirror device, each pixel of the DMD represents a mirror that is controlled to direct light toward viewing screen 60 or away from viewing screen 60 in accordance with a data signal providing data input 44 as shown in Figure 3A and image data 72 as shown in Figure 3B. (9:43-45; 9:56-10:20; 8:19-53) The specification discloses a variety of ways in which “spatial modulation” can occur. “The spatial modulation can optionally be performed with analog or binary levels or gradations, according to the type of modulator device which is used. Nematic liquid crystal modulators, for example…allow for analog "grey levels",....If a binary modulator device is used for spatial modulation "grey levels" are achieved by controlling the duration of the illumination, and/or the intensity of the light incident on the spatial modulator.” (7:38-41) ”In this context, LCD features an organized structure of anisotropic molecules, for which the axis of anisotropy is rotated by the application of voltage, thereby rotating polarization.” (9:27-30) The specification further discloses varying intensity by varying polarization in LCD spatial modulators. (9:22-25) “Examples of the binary modulation type include, but are not limited to, DMD, FLC, quantum well modulator and electro-optical modulator. DMD (digital micro-mirror device) is an array of mirrors, each of which has two positions, either reflecting light toward a viewing screen 60, or reflecting light away from viewing screen 60.” (9:41-46)

		At the time of the invention, one of ordinary skill would have understood that the term "spatially modulating" encompasses each of the means of varying light as a function of position as set forth in Genoa's proposed construction.
said light of at least four colors in accordance with a **data signal**	a signal representing an image in terms of a plurality of pixels, each having exactly three component values, e.g., RGB, XYZ, YCC, etc.	The data signal providing digital image data 72 as shown in Figure 3B is a signal that presents three component values for each pixel (*e.g.*, Red, Green, Blue or "RGB"). (10:39-63) The input data is shown in Figure 6B as "RGB input data." (14:34-38). The RGB signals may be transformed into other combinations having three component values using "YCC-type data formats." (10:60-63) In either case, the input "data signal" is a signal representing pixels, each of which has exactly three component values, *e.g.*, RGB or YCC-type data. (11:16-18) At the time of the invention, one of ordinary skill would have understood that the term "data signal" to have the meaning as set forth in Genoa's proposed construction.
to **produce said color image**.	construct an image from a plurality of pixels, at least some of which are made up of at least four non-white and non-black colors	By means of the steps of color transformation 74, gamma correction 76, frame buffer 78, and timing and control 66, all as shown in Figure 3B, the three component (*e.g.*, RGB) data signal providing image data 72 is converted so that, by means of spatial modulator 56, it provides a color image made up of individual positions 68 on the viewing screen 60. Color image is a full color image made up of more than three primary colors. "The human viewer integrates the sequential stream of the primary images to obtain a full-color image with a wide gamut of colors when viewing the image as projected onto viewing screen 60." (10:16-21) Under Figure 6B, this transformation commences with a three color RGB input and ends with a seven color data output. In any event, the result is the construction of an image from a plurality of pixels, at least some of which are made up of at least four non-white and non-black colors. (10:18-20) Thus,

		"the use of such [RGB or YCC-type] requires the data to be transformed into a format which is suitable for a display including at least four primaries." (14:16-18) At the time of the invention, one of ordinary skill would have understood that the term "produce said color image" to have the meaning as set forth in Genoa's proposed construction.
2. The method of claim 1, wherein each of said at least four light colors is produced at least once during one rotation of said color wheel.	*See* Claim 1. Otherwise no construction needed	One of ordinary skill would understand that the terms in this claim element have their ordinary meaning.
3. The method of claim 1, further comprising operating a motor attached to said color wheel for rotating said color wheel.	*See* Claim 1. Otherwise no construction needed	One of ordinary skill would understand that the terms in this claim element have their ordinary meanings.
4. The method of claim 1, further comprising projecting said filtered light onto a viewing screen.	*See* Claim 1. Otherwise no construction needed	One of ordinary skill would understand that the terms in this claim element have their ordinary meanings.
5. The method of claim 1, wherein said **spatially modulating** said light comprises	*See* Claim 1.	*See* Claim 1 for the construction of "spatially modulating."
selectively activating a spatial light modulator	controlling the individual pixels of	The individual pixels of the spatial light modulator are controlled. "The light beam is spatially modulated by spatially modulated mask 56 so that the apparent brightness of each primary color varies at different portions of viewing screen 60, typically

		according to each pixel of the image. Each position 68 on viewing screen 60 is preferably associated with a certain pixel 70 and spatially modulated mask 56. The brightness of that position is determined by the relevant data pixel in the image." (10:7-14)
6. The method of claim 5, wherein said spatial light modulator is **a digital micro-mirror device** (DMD).	*See* Claims 1 and 5. a two-dimensional arrangement of mirrors, each of which has at least two orientations, each of which orientations reflects light in a different direction	(*See* 9:43-45)
7. The method of claim 5, wherein said **selectively activating** said spatial light modulator comprises activating said spatial light modulator to sequentially modulate the light of said at least four different colors	*See* Claims 1 and 5. controlling the individual pixels of	*See* Claims 1 and 5.

8. The method of claim 1, further comprising **converting**	*See* Claim 1. transforming	The "color transform" module 74 as shown in Figure 3B converts the three-color input to an output of more than four primary colors by transforming the data. (11:16-21; 14:16-18; 16:62-63 (transformation of RGB data to a format suitable for displaying with at least four colors).
three-color data representing said color image in terms of three colors	an image represented by a plurality of pixels, each having exactly three component values	*See* Figure 3B image data 72 and Figure 6B; description of data flow in which data representing color image in terms of three colors is transformed. (10:39-11:21)
into **converted image data representing said color image in terms of said at least four different colors**.	"**converting three color data…into converted image data"** means, for every pixel in the input data, transforming each three-component pixel into a pixel having at least four (potentially non-zero) colors, each of the at least four colors corresponding to a non-white and non-black filter	The input data is "a signal representing the R, G and B values of pixel-after-pixel, line after line for a film frame." (10:45-46; 54-55) Data arriving in analog video signal form is transformed into digital data. (10:42, 65) The "digital RGB image data or YCC-type data is then manipulated in a multi-color transformation module 74 . . . into a color format which includes data for each color of color filters 52, with N-bits of data per color (for example, seven colors, of which one is white, and 8 bits per color)." (11:16-21) Thus, each pixel of the converted image data has at least four color components. The values of some of those component colors may have a zero value, but all of the component colors have potentially non-zero values, each of which corresponds to the at least four colors represented by the filters in the color wheel depicted in Figure 4A. (12:42-46;15:24-41)
9. The method of claim 8, further comprising: receiving image data representing said color image in terms of said at least four colors; and generating a **formatted data signal** including a sequence of	*See* Claims 1 and 8. an arrangement of the converted data signal	The converted data is loaded into a frame buffer and format module 78 which arranges the stream of data in a format consistent with the electronic requirements of spatially modulated mask 56. (11:39-42) The frame buffer is divided into bit planes, each bit of which corresponds to one pixel on the spatially modulated mask. (11:47-51) Each bit plane corresponds to a color such that, "if a pixel is to have a component which includes a particular primary color, that pixel is represented by a particular bit on the appropriate bit plane that features that primary color." (11:52-55*)*

		See 11:39-46: "The corrected data is then loaded into a frame buffer and format module 78 which arranges the stream of data in a format consistent with the electronic requirements of spatially modulated mask 56. Frame buffer and format module 78 is a memory device for holding the data of the image. Typically, the data is held in the same geometrical arrangement as the pixels of the image, and of spatially modulated mask 56."
color data **arrays**, each array including data representing at least part of said image data corresponding to one of said at least four colors.	multi-dimensional data structures or arrangements of data	*See* 11:47-60: [T]he frame buffer itself, of frame buffer and format module 78, is preferably divided into bit planes. Each bit plane is a planar array of bits, in with each bit corresponds to one pixel on spatially modulated mask 56."
10. The method of claim 9, wherein said **spatially modulating** said light comprises	*See* Claims 1, 5 and 9.	*See* support stated as to Claim 1.
selectively activating a spatial light modulator based on said formatted data signal to produce a light pattern corresponding to said color image.	controlling the individual pixels of	*See* support stated as to Claim 5.